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LECTURES

ON

FISHES, FISHING, &c.,

DELIVERED AT THE

COUNTY FISHERIES EXHIBITION,

HELD AT

TRURO, CORNWALL,

1893.

TRURO:
LAKE & LAKE, LTD., PRINTERS AND PUBLISHERS.
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Cornwall County Fisheries Exhibition, 1893.

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BY

Prof. G. B. Howes, J. T. Cunningham, A. Burden,
B. Ridge, W. Garstang, G. H. Fowler, O. Greig,
G. E. Matheson, Matthias Dunn, T. H. Bickerton
and J. M. R. Philpots.

TRURO:
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1895.

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LECTURE 1.

(Delivered on Tuesday, July 25th, 1893.)

FISH

In Relation to their Surroundings

BY

PROFESSOR G. B. HOWES,

(*Royal College of Science, South Kensington*).

Chairman:—JOHN CHARLES WILLIAMS, ESQ., M.P.

FISH IN RELATION TO THEIR SURROUNDINGS.

Professor Howes said: I imagine that to most of us the word fish suggests a scale-clad creature, to be more or less admired while in the water, to be despatched on removal from it,—withal a none too fortunate animal. Of these scaly fishes there are some eight thousand odd species to-day inhabiting the globe, and bountiful nature provides them as food for the body and as food for the mind. It is in the latter association that I wish to speak of them to-day, and the gist of a great deal that I have to put before you depends upon what we are to understand by a fish; upon the proof that the fish may be sensitive to immediate change in its environment, and that it may be specially modified in accordance with the conditions of its existence.

What, in the first place, are we to understand by a fish.

It has long been customary to distinguish so-called water-breathing from air-breathing animals, and while we refer fish to the water-breathing series, we refer creatures which like ourselves live on land to the air-breathing one. When we look a little more closely into the facts however, we find, within the limits of a reservation which I shall put before you, that if free oxygen be withdrawn from the water, life is impossible to the fish; and this is but one way of proving that although the fish lives in water it is dependent upon oxygen for the maintenance of its life. I take it that we all know that the function of respiration in the fish is carried on by four pairs of gills—structures

borne upon the head region, and protected by the familiar flap or gill-cover. Inasmuch, therefore, as the fish is dependent upon oxygen for the maintenance of its life, and as life is only possible so long as these four pairs of gills remain functional, we may sufficiently distinguish the fish as a creature breathing by four pairs of gills, interference with the functions of which is fatal.

Having ascertained what we are to understand by a fish, we next approach the question of the sensitiveness of the fish to change in its environment. Those of us who are in the habit of dealing with fish know full well that there are many of these which, like other animals, will change colour in accordance with variation in their surroundings. Mr. Cunningham has lately shown that the common sole will do this; and it also true of the familiar frog. If you put the Frog into a dark room it assumes a darker colour, and if you expose it to the light it becomes proportionately lighter in colour. We are thus enabled to adduce ready proof that, during life, the fish, in common with other animals, may change colour in response to variation in the conditions of its environment. Mr. Cunningham has gone a step further, and, as the result of an exceedingly beautiful experiment, has shown that the common flounder will change colour to even a more marked degree. It is well known that whereas the back of a fish, which is directed towards the light, is usually darkly coloured, the under-side, or belly, which is directed away from the light, is generally white or whitish. It occurred to Mr. Cunningham that in the flounder, an animal in which the under-side is *par excellence* "colourless," colour should appear on the colourless side, if subjected to the direct action of light. He therefore placed some young flounders in a tank, and caused reflected light to be presented towards the underside of their bodies. Within a few months he saw pigment appearing, and he has now in his possession animals which, in the courrse of time, have become coloured over

well-nigh the entire colourless surface. The facts which I have put before you furnish proof conclusive that fish may be sensitive to change in their environment; and it remains to be shown that they may be sensitive to immediate change. Passing to this question I wish to draw your attention to one of the most interesting fishes living—if, indeed, it is still living—and to say a word or two concerning some most interesting observations made years ago by our American cousins. They found that the American Shad normally spawns at a temperature of 60 degrees Fahrenheit; and they have recorded the fact that if the temperature be either raised or lowered by five degrees, the fish will immediately take to the sea. So that we have it proved that a variation of five degrees Fahrenheit will cause fish to migrate for purposes of reproduction. The fish to which I wish more especially to refer is known as the Tile fish (*Lopholatilus chamæleonticeps*). It was originally found in large numbers on the North East Coast of America, in water averaging 50 degrees Fahrenheit. It is a large cod-like fish, reaching 50 or more pounds in weight. It was discovered in 1879, and for three years became one of the most important food fishes of the time. In the spring of 1882, there raged over the the North East Coast of America a most terrible storm. The water in which this animal lived is a relatively warm belt which impinges upon the Gulf Stream; and on the morning following the storm the sea was observed to be strewn with countless millions of these fish. Instead of appointing a Royal Commission to enquire into the matter and report years hence, the Americans organised an Expedition and sent a ship out, to see what she could find. The vessel ploughed, we are told, over 150 miles, straight ahead, through the dead carcases of tile fish, and the data furnished by the officers of that ship and of others visiting the same locality, have proved that the area over which these dead fish were strewn, was not less than from 5,000 to 7,000 square miles—approximately equal to that from the Land's End to Wiltshire, including the counties of Cornwall, Devon, and Somerset.

The special interest of this case lies in the fact that during that single night this fish was absolutely exterminated, so far, at any rate, as the area alluded to is concerned, for the reports that have been published during succeeding years have shown that the fish has not been since met with in its old habitats. Our American friends naturally thought that this summary extinction was due to volcanic action; but if this were so, it is only natural that other fish, known to be living in the same water, should have been destroyed. In the absence of all but here and there a stray carcase of any other fish, they have come to the conclusion that the destruction was due to a change (and most probably a reduction) in the temperature of the water, brought about mainly by a churning action and by the fact that they had just passed through an excessively hard winter, which had left a quantity of ice as its legacy. The possibility that this is a sound conclusion is the greater from the study of more familiar facts concerning the common Cod. When captured these fish are frequently placed in wells in the bottom of the boats, which are exposed to the sea beneath, and it has been found that under these circumstances they may become numbed on being brought into contact with cold water. We thus see that a fish may be so sensitive to immediate change in its environment, that in a single night a species destined to become one of the most important food fishes of the world may be destroyed. An interesting fact bearing on this question is reported from Tasmania. For many years efforts have been made to acclimatize the English Salmonidæ to Tasmanian waters. With the Trout there has been success; but although some thousands of pounds have been spent in the endeavour to acclimatise the Salmon, it has been found that when the young Salmon have been reared to the migratory stage, they disappear. The temperature of the sea into which the River Plenty flows, is found to be 10 degrees higher than that around Great Britain; hence it is argued that the young Smolt have been

lost (probably not killed) in the attempt to find the colder water to which their ancestors were accustomed. And the proof that the fish may be thus sensitive to immediate change in its environment, throws a flood of light on the total extinction of whole families of fishes in past periods of the world's history, when the telluric conditions were far less stable than at present.

I turn next to the question of special adaptation to the conditions of existence, but let me first caution you against imagining that all fish are as sensitive to change in the temperature of the water as those to which I have alluded. You have only to go to the rock pools on your own coast for proof to the contrary; for there you will find that the Butter-fish (*Centronotus*) and the common Blenny may survive a rise of from 10 to 15 degrees in almost as many minutes when the sun is shining. Dealing now with fish in relation to special adaptation to the conditions of existence, I would first draw your attention to the Angler or Fishing Frog (*Lophius piscatorius*), a large and familiar animal with a mouth well-nigh as wide as its body is long, which may reach to a length of from four to five feet. Four species of this genus are known, and the peculiarity about the common one is that it bears on its back a series of filamentous appendages, which, being thrown into motion, act as a lure to other fish and serve to entice them to certain death. These fish live in shallow waters, of from three to five fathoms. The edge and exposed surfaces of the bodies of these animals bear, one or both, out-growths, which take on much the appearance of small organisms living at the sea-bottom, and also lure the innocent prey. There can be no doubt that these fish have become specially adapted to the conditions of their existence, by the development of these special appendages; and the success of the essay may be guaged from the fact that in the stomach of one there were found 75 herrings, and in that of another 21 flounders and a dorey. A still clearer case of special

adaptation to the conditions of existence is furnished by a Sea-horse living on the Australian shores. It is represented by two species, one of which we know to be brightly coloured. It lives among sea-weeds, and its body is frayed out into a series of fleshy prolongations which simulate fronds of these plants, in accordance with which peculiarity it has received the generic name of *Phyllopteryx*. We do not know the actual colour of the species before us (*P. eques*) despite the fact that its gaudily coloured photograph is to be found among the appurtenances of the popular lecturer, but we know that its ally is approximate in colour to the plants among which it lives. An allied, but more remarkable case is that of a prawn living in the mouth of a gigantic anemone, met with also on the shores of Australia. Its body is white with red bands, and the extraordinary thing is that a small fish (*Amphiprion bicinctus*), which also inhabits the Anemones' mouth, is similarly coloured. The sea anemone itself (*Discosoma*) may be emerald green or a delicate purple. We cannot say why it is that the fish and the prawn are so far alike; but there it is—living under the same conditions they have assumed the same colouration, and the most rational conclusion is that the red and white banding (which, in contradistinction to the case of the sea-horse and the sea-weed, effects a marked contrast to their surroundings) may enable them to act as snares to small animals, which fall a prey to the death-dealing powers of the anemone, and on which it and they are, in the end, dependent. In concluding these preliminary remarks, I would call your attention to a fish dredged up in the Bay of Bengal, at 490 fathoms (*Bathypterois Guentheri*), a member of a group which is not uncommon in the Southern Hemisphere at depths varying from 500 to 2,000 fathoms. It agrees with the creatures familiarly known as the Tassel Fish (*Polynemidæ*) in having some of its fins prolonged out into fine filaments. This fish has an eye so small as to be overlooked at first sight, and although it is by no means the only fish in which a great reduction of the visual organ is met with, we are led to enquire whether

in this particular case that may not be associated with the development of the filaments in question—whether, that is to say, it may not mark a change similar to that which the cat has undergone in relation to its tactile moustachios (usually but erroneously called whiskers). The tassel fishes are represented by a number of species, occurring in the Indo-Pacific and the Tropical Atlantic seas. In the genus *Polynemus* we meet with forms (ex P. *sextarius*) in which the filaments, which are products of dismemberment of the pectoral fins, are short, and the eye is not reduced; while we meet with others (ex. P. *paradiseus*), in which the filaments are excessively elongated, exceeding the body in length, and the eye is somewhat reduced. In the so-called blind Tassel fish (*P. cæcus*), of Queensland, in which the filaments are greatly elongated, the skin covering the eyes is said to be thickened (it may be in association with the greater need of protection against the action of the muddy water of the Tropical estuaries which it frequents). In consideration of these facts we have to face a serious and definite consideration. Inasmuch as the elongation of the filaments is accompanied by the reduction of the eye, it is clear that we have a correlation of adaptive change between these two organs. In one species we have the normal eye, and little elongated filaments; in the others the reduced and beclouded eye, and the excessively long filaments; and we are driven to the consideration of Darwin's Theory of descent with modification. One everywhere finds that nothing is easier than to misunderstand the statements of others. One frequently hears people placidly assert that Mr. Darwin taught us that men came from monkeys; but Mr. Darwin never taught anything of the kind. What he did teach was that if community of structure implies community of origin, man and the monkey must have had a common ancestor—which is a very different thing. And so it is with these fishes; the differences between them appear to be just those indicative of an origin from a common ancestor, by diversity of modification; and it may well

be that the reduction of the eye in the Bengalese fish has been associated, under a correlation of structural modification, with the attenuation of the fins to form tactile organs. I desire to lay stress upon this, in anticipation of another essential consideration which I wish to place before you.

We now pass on to consider certain more conspicuous adaptive organs by which some fish have become specially fitted for the conditions of existence. We are all more or less familiar with the fact that many fish are luminous. As a general rule the luminous organs are more or less regularly distributed over the body, but in some cases we find them restricted to certain areas of it. Ranging over temperate and tropical seas, at varying depths attaining to more than two thousand fathoms, we have a series of forms (*Scopelidæ*) the bodies of which are beset by a series of spots, each one of which marks the development of a luminous organ. In contradistinction to these forms we have others in which the luminous organs are restricted in a very remarkable manner. Two of the most popular of these have been obtained from the South Coast of Japan at a depth of 345 fathoms, and the North Atlantic at a depth of 2,400 fathoms—species of the genus *Ceratias*, a most extraordinary fish allied to the Angler. There is developed upon the top of the head a long filament, which in the Japanese species (*C. carunculatus*) projects forwards and bears what is believed to be a luminous organ at its end. I have heard it said that this fish carries its luminous organ in front of it, and that the pendant condition of that is an arrangement by which it is enabled to light up the sea-bottom, in order to detect the presence of its prey. A very pretty theory! but, like many other pretty things, it would appear to be only skin-deep. In the Atlantic species (*C. uranoscopus*), the organ is backwardly directed, whereby the fish probably carries it over its tail instead of its head; and it is impossible to see how, under the circumstances, it could use it as a lantern to illumine its path. What then is

the meaning of this luminous organ? When we look abroad we find that luminous organs are by no means confined to fish; and we meet with the significant fact that some fishes which do bear them, instead of having a large eye, calculated to appreciate the feeble rays of light which they emit, have a very small eye; and inasmuch as the small eye and the supposed lamp may co-exist, there would appear to be a weak point in the argument, if, as is commonly believed but not proved, all is dark in the depths at which these creatures live. We meet with luminous organs in crustaceans, cuttle-fishes, worms, and jelly-fishes at least, among marine animals, and they appear to exist among the sponges. Now, whatever is to be said for the animals named other than the sponge, there can be no doubt that that is destitute of eyes, and not, therefore, in a position to appreciate these rays of light, supposing them to be emitted for the purpose suggested. These facts go far to prove that the luminous organ is not a lamp, but a snare—a structure which is used as a means of attracting smaller creatures upon which the luminous animal preys. Many luminous animals live during the day at more or less great depths, and at night come to the surface in search of food. They there meet with numberless things and creatures which are perfectly transparent. They meet with certain small Crustacea (*Copepoda*) which are among the most fantastic of nature's productions, and they meet with more especially larvæ of certain other fishes, some of which bear filamentous outgrowths. One of the most remarkable of these is the larval *Fierasfer*—an animal which, in its adult state, utilises the body of a sea-cucumber, or some other host, as a protective habitation. In its young condition it has upon its back a branching filament or outgrowth, which bears certain enlargements and is kept in a state of constant agitation. No one has yet shown what is the use of this filament; it is not phosphorescent, and, for my own part, I cannot resist the conclusion that it is functional in luring other creatures as food, if not for the purpose of warding off

attack as well. It would be interesting to enquire whether it may not be akin in its functions to the hairy outgrowths or "tussocks" on the backs of our commoner catterpillars. It has been found, by experiment, that if the catterpillar of the vapourer moth (*Orgyia antiqua*) be offered to a hungry lizard, the creature will either not attack it, or, if it does so, it will attack it in the spine-bearing region, rather than in the part covered by these outgrowths of bristled hairs. I mention this by way of suggesting that these fleshy appendages may be serviceable to the fish larva as a means both of attracting smaller animals as prey, and of warding off the attacks of larger animals which would otherwise devour it. It is clear from all this that the phosphorescent fish which prowls about at night meets with pretty much the same experience as do certain other animals that have acquired that habit. It meets with creatures which can be quickly seen through; with others that have nothing better to do than bedeck themselves—for what purpose it is in some cases impossible to say; and, in the person of the fish larva, it may meet with more than its match.

These phosphorescent organs attain a considerable degree of structural modification. In their simpler forms they are borne upon loosely diffused areas of the skin; but in their more complex forms they are symmetrically arranged, and possessed of pigmented investments and a lens--appurtenances of a dioptric category. Between the more simple (diffuse) types and the more complex (ocellated) ones we meet with others in which the transition condition from the simple to the complex form is represented. The smallest of known phosphorescent fish is a little creature (*Astronesthes*) common in the Atlantic and Indian Oceans, at depths reaching to 2,500 fathoms. It is asserted that in *A. niger*, from the West Coast of Africa, there occur side by side three diverse types (i.e. that there are represented in the one body the leading stages in the evolution of the organs in question) a matter of considerable interest if the different types of phosphorescent organs stand in a similar relationship to the

different types of filamentous ones occurring in the tassel fishes. Before dismissing the luminous organs there is one very important fact to which I wish to allude; viz: that they are glandular in nature, and consist of aggregates of structures which may be compared to the small glands which secrete the sweat or perspiration of our own bodies.

I desire now to say a word or two concerning an apparently very different set of structures, which are purely adaptive in their functions; I refer to electrical organs. Many of us have heard the story of the Electric Eel of the rivers of tropical America. It is said that in order to catch these eels, which may reach a length of six feet, the hunters are in the habit of riding into the water and allowing the fish to discharge their electricity around the fetlocks of the horses. No one has, however, succeeded, in recent years, in confirming this narrative; and hence the story of the eel and the fetlock must be provisionally discredited. As distinguished from these eels we have our Torpedos. The torpedo may be regarded as a kind of skate with an electric organ situated between the head and the great swimming pectoral fins. The electric organ consists of a series of columns, each of which contains a great aggregate of plate-like structures under control of the nervous system. These are termed electric plates; each of them lies parallel with the long axis of the body and the current passes in a direction at right angles to the same, that is from the belly towards the back, or *vice-versa*. The nervous apparatus which controls this organ is a relatively colossal one, for, as compared with the nervous apparatus of our own body, it is more than akin to that controlling both our arms and legs. It has been estimated that in the four electrical nerves of this fish there are present from 50,000 to 60,000 nerve fibres. It may appear that this fact is but a trivial detail, but it so happens that when we pass from the torpedo to the consideration of the other electrical fishes, it becomes one of supreme importance, as we shall see. We have the electric fish of the Nile—the

genus *Malapterurus*, and another, the *Mormyrus*, known as the "Nile Pike," of which there are a great number of species inhabiting the fresh-waters of Tropical Africa. Among recent discoveries in systematic ichthyology considerable interest attaches to those which have rendered it more and more clear that herrings and pikes are directly related forms. No one would imagine this from a mere examination of our familiar types, so different are they in general appearance. As a matter of fact, however, they are proved to be closely related, and amongst those fish which as it were weld them together upon certain structural points, we have to reckon this Nile Pike. On examining the electrical organ we find that in the former of the two Nile fishes its structure is essentially the same as in the torpedo, except that the electric plates are set at right angles to the long axis of the body, and that the electric discharge, instead of passing vertically, travels from the head to the tail, or *vice versa*—that is parallel with the long axis, the opposite ends of the body being in the opposite electrical states, instead of the opposite faces as with the torpedoes. A most astounding fact, however, is that in place of the 50,000 or 60,000 nerve fibres which control the activity of the electrical organ in the torpedo, there is but a single fibre in the *Malapterurus*. Comparing this electric fish to an ironclad, the conditions, from a point of view of efficiency, are infinitely more remarkable than if say the cabin boy were competent to perform the combined duties of officers and men under fighting orders. This difference between the nervous apparatus of the Nile fish and the familiar torpedo involves a problem the real nature of which the mind absolutely fails to grasp. It is sufficiently established that in both the Torpedo and Malapterurus, the functional portion of the electrical organ consists of metamorphosed muscular tissue. We turn now to the Nile Pike, which is also electrical. In this fish the muscles are throughout unaltered, and those structures which perform the electrical function are most probably glandular

in nature. It has at any rate been shown that instead of lying in the deeply-seated tissues of the tail and body, they are restricted to a definite zone, lying immediately beneath the outside skin. We eagerly await further investigation, more especially into the development of the electric organs; but if it be true that while in other electrical fishes these structures are metamorphosed muscular organs, in the Nile Pike they are modified glands of the skin, there is an end to any notion that the electrical fishes may be genetically connected. The principle of descent from a common ancestor appears to break down here, and it is a fair conclusion that there has gone on an evolution of organs of two totally different structural types, for the performance of the same function. In view of the apparent origin of the glandular type of electrical organ, as it exists in the Nile Pike, from cutaneous glands, a comparison suggests itself with the phosphorescent organ in its simpler and more diffuse types; and it appears to me by no means unlikely that future enquiry will prove these organs to be diversely modified forms of the same apparatus, electricity and light standing in a relationship, anticipatory, as it were, to that which they have recently been forced to assume at the will of man. Approached from this standpoint, the fact that the use of the electric lamp in tow-netting has been found to attract small crustaceans and other organisms of the kind that luminous fishes which approach the surface appear likely to feed upon, lends additional support to the conclusion that the luminous organs of fishes are, for the most part, snares.

We saw at the outset that we might define a fish as a creature possessed of four pairs of gills, interference with the functions of which is fatal to its existence. If this is the case we turn with much curiosity to certain tropical fishes which are called upon to survive the effects of drought, and enquire what methods they adopt to that end. I daresay most of us are familiar with the story of the Climbing Perch. This fish (*Anabas scandens*) if placed captive in an aquarium

cannot be kept in it for a single night, except by force. Doldorff in 1779 found a Climbing Perch in Eastern India five feet up a palm tree, and ingenious writers on Natural History, improving upon this observation, have gone so far as to suggest that the fish ascends the tree to obtain food. Although this fish readily leaves the water for migration overland, no one has since succeeded in inducing it to climb a tree; and hence the heresy of the climbing perch must be held in abeyance. This climbing perch is one of a number of fishes, mostly confined to the equatorial zone, over whose gills there is present a sac, which communicates with the mouth and lodges an outgrowth of the gills known as a labyrinthiform organ. If we survey this series of fishes (*Labyrinthici*) we find at its top creatures like the climbing perch, and at the bottom animals in which, while the sac is considerably developed, the so-called labyrinthine organ is not labyrinthiform at all, but merely a feeble outgrowth of the gills. We find, in fact, structural differences which point to a belief in the theory of descent with modification, along similar lines to those which served us in dealing with the tassel fishes. It was originally thought that this labyrinthiform organ, because of its sponge-like character, might be used to enable the animal to keep its gills moist when out of water. Not only will these labyrinthicine fishes deliberately leave the water, but they are characteristically in the habit of migrating from place to place. In the rainy season they pass from stream to stream, and pool to pool; but during the hot season they bury themselves in the mud. Travellers visiting the districts in which these creatures are found have long ago discovered that in walking over them at night, when all is quiet, a gurgling sound is audible, and that on digging down whole shoals of the fish are to be found, breathing not water but atmospheric air. How are we to reconcile these facts with the idea that the labyrinthiform organ is sponge-like in function, holding water in suspension? Firstly, a word or two concerning some fish found in tropical latitudes in which

there is present at the back of the mouth a sac, having essentially the same relationship to the parts of the head as that in the fishes which I have just described, but no labyrinthiform organ. Conspicuous among the animals to which I refer is an Indian fish called the *Saccobranchus*. In that creature the sac in question passes along the side of the body, and terminates a little short of the tail. If it is punctured, air, and not water, will escape. Another fish in which this pharyngeal sac is present, is an animal called the *Amphipnous* or air-breathing eel. This fish also occurs in the fresh waters of India, and in it the sac is very much shortened. These creatures migrate in the manner of the labyrinthicine fishes to which I have alluded, and it is said that if you place the sac bearing eel in an aquarium, you have to cover that in order to prevent it from escaping. As it normally exists, it regularly rises to the water for the purpose of gulping in air. Seeing now that the so-called labyrinthicine fishes breathe air and not water when on land, and that in allied forms the pharyngeal sac on being punctured emits air and not water, are we not justified in looking upon this adaptive apparatus as functionally a lung?

Before I pass to the ultimate consideration of this question, I would refer to a fish found in the rivers of tropical America and the West Indies,—the *Callichthys*, a creature which also rises to the surface of the water to breathe air, and which, it is said, will also make its escape from an aquarium. It is a beautiful and densely armoured animal, and is in the habit of swallowing the air and passing it through its intestine. Now, if we are to define a fish as an animal possessed of four pairs of gills, interference with the functions of which is fatal, these air-breathing fish in a certain sense of the word are not fish at all; and we have to ask is it, or is it not, proved that the pharyngeal sac, the vascular intestine, and the labyrinthiform organ, are air-breathing apparatus? In considering this subject we may here best do justice to the memory of a man whose name

will always occupy a foremost position where British and Indian fishes are concerned. I refer to the late Dr. Francis Day. In the course of his career as an Indian fisherman, it occurred to him to experiment on the labyrinthicine and pharyngeal-sac-bearing fishes. He commenced by tying up their heads. If the head of an ordinary fish be bandaged up death will rapidly ensue; but in these labyrinthicine and pharyngeal-sac-bearing forms, it has been proved by Dr. Day, and others whose enthusiasm he aroused, that with the head bandaged the creatures will live, if they have free access to the surface. If, however, they are deprived of this, they invariably die; and in the case of those which yielded the best results, it has been found that whereas a period of less than a quarter of an hour's complete submergence might cause death by asphyxiation (*Anabas*), life might endure for from 16 hours (*Anabas*) to 5 days (*Amphipnous*) after complete removal from the water. It is thus proved that in these fishes we are dealing with creatures which may be drowned almost as readily as we can drown a dog; while fish in the strict sense of the word, they are, in a sense, not fish at all, inasmuch as interference with gill respiration, which is fatal to the ordinary fish, is to them somewhat a matter of indifference. In these "air breathing" fishes we meet with a condition in which the blood-vessel which carries the blood to the lung-like organ, has similar relationships to the heart and great arteries to that which is now carrying the blood from your heart and mine to our central organ of respiration. It is customary in India for conjurors to hawk certain of these fishes about the country. One of them (*Ophiocephalus*) is termed the "walking fish," in accordance with the conjurer's tale; and imposters of another order are in the habit of invoking them in defence of their belief in the descent of fish from the clouds. If subjected to conditions under which the water is caused to evaporate, these fish, lying buried in the mud, establish a communication with

the outside air, and so long as that is possible they continue to breathe this. One conclusion which assuredly follows from the foregoing facts, is that the labyrinthiform organ is not a sponge-like structure used for the purpose of keeping the gills of the fish moist while out of water, but rather the leading portion of an air-breathing apparatus.

There exists at least one fish, which there is reason to believe has acquired yet another special mode of respiration. I refer to a grotesque little goggle-eyed creature, known as the *Periophthalmus*, common on the shores of the Indian and Australian seas and occurring on the American side of the Atlantic. The roots of the mangrove are a favourite resort of this genus, and its species are notorious for leaving the water when in search of food. When at rest, this fish lies with its body out of the water, its tail-end being alone completely immersed. It becomes now a question whether this immersed tail is, in reality, an accessory organ of respiration. Within the last three or four years it has been found that whereas complete immersion of some 42 hours leaves the animal none the worse, if the immersed portion of the tail be painted with gold size, a maximum period of 18 hours ends its existence. Therefore, seeing that when the tail of this fish is deprived of the power of effecting a gaseous interchange with the surrounding medium in which it is immersed death ensues, there is good reason for regarding it as an accessory organ of respiration. As a physiological fact, this caudal respiration is nothing new, for we have long known of other animals which in their young state use their tails for that purpose. A poet has said :

> The vital air pervades the swarming seas and heaving earths,
> Where teeming nature broods her myriad births ;
> Fills the fine lungs of all that breathe or bud,
> Warms the cold heart, and dyes the gushing blood ;
> With life's first spark inspires the organic frame,
> And, when it wastes, renews the subtle flame ;

and I venture to think that that poet was not far wrong.

A word or two now, by way of application and conclusion. I presume we are all ready to admit ourselves the wiser for the study of facts such as I have put before you; but it may be doubted how much we are the better for it. I think we can only be said to be the better for the study of natural phenomena when we can apply the facts to some more or less directly beneficial purpose; and when we can deduce from them generalized statements expressive of the workings or "laws" of nature.

We have seen that while the doctrine of descent with modification from a common ancestor will suffice to explain the various conditions of more especially the tassel fishes, it is at any rate apparently insufficient to explain the independent evolution among remotely related forms of electrical and accessory respiratory organs. Among the animals possessing the pharyngeal sac, we have the genera *Saccobranchus* and *Amphipnous*,—the first a member of the family known as the Siluroids, mostly restricted to tropical latitudes, and the second, of that of the eels, which are world-wide and cannot conceivably have a direct generic relationship to the Siluroids. The conversion of the intestine into an accessory respiratory organ, which we have considered in the *Callichthys*—a new-world Siluroid—is again met with in the Indian genus *Lepidocephalicthys*, which is a Loach and at best but remotely related to its ally. In face of these facts the conclusion is, I think, inevitably forced upon us that there has been effected an independent evolution of the particular form of organ in each of the three great groups named. In seeking to solve this difficulty, I would direct your attention to a doctrine which we owe originally to Dr. Anton Dohrn, viz: that of change of function, which presupposes that functional changes of the order under consideration may be here and there effected, as the result of perfectly independent modification correlative with that of other organs of the body. Let us now proceed to

consider how far the facts before us will bear this out; and I must be content to deal with the electrical organs alone. Is it, or is it not, the case that evidence is forthcoming to show that these may have been developed as the result of functional change—in correlation with a loss of function by this or that particular organ of the body? In dealing with this question I may satisfactorily refer you to our common Skates or Rays. They possess an electrical organ, known to be an efficient apparatus of discharge, not in the head or body but in the tail. The most striking characteristic of the body of these fish is the enormous expansion which their front or pectoral fins have undergone, for the purpose of locomotion. In an ordinary fish, as in the sharks and to a lesser extent in the torpedos among fish closely allied to the rays, the propulsion of the body is effected by the movements of the tail; but in these creatures it is effected by the movement of these extended pectoral fins; and the fact that under these circumstances it is the tail and the tail only which has become converted into an electrical organ, stands out as one of startling interest, and I think fully supports Dr. Dohrn's hypothesis of change of function, and justifies us in accepting that as readily explanatory of the difficulty we have in mind. In these skates and rays the electrical organ is not invariably present. There are the Eagle Rays of the tropical seas, in which the tail has practically disappeared, being represented by a filamentous vestige; there are the common Sting Rays in which the tail bears, instead of electrical organs, one or more gigantic spines; and there are others in which the tail is converted into a greatly attenuated whip-lash. Seeing therefore that the conversion of the tail into an apparatus of electrical discharge, is one of a series of changes which these fishes have undergone in connection with the loss by that organ of its swimming function, Dr. Dohrn's hypothesis becomes the more acceptable.

In concluding, I would draw your attention to the fact that in certain herrings living in central and tropical latitudes, we meet with an accessory organ of the pharynx, which suggests the sac of the Saccobranchus and the Labyrinthici. This structure has received but little attention, but whereas in some of these herrings (the West Indian *Chupea thrissa*, and the Indo-Pacific genus *Chanos*) it is a comparatively small affair, in the herring pike of the Upper Nile (*Heterotis*), it is coiled into a spiral and greatly elongated. Within the limits of the herring series we meet with still simpler conditions of this sac, in which there is no indication of this coiling, and with others which furnish the transition stages in its evolution. It is customary to regard the sac of these herrings as an accessory organ of respiration, but there is no proof that it performs such a function, and one great desideratum in ichthyology is a knowledge of its use. We have seen that in those tropical fishes which breathe air, the accessory organ of respiration is most generally either a pharyngeal sac or a structure lying within that, and this renders it likely that we shall ultimately arrive at a demonstration of some direct relationship between this pharyngeal organ of the herring, and the saccular constituent of the accessory respiratory organ of the Saccobranchoid and Labyrinthicine types. It is the pharynx which has in all become modified.

I fancy I hear someone remark—"this is all very well; you have told us pretty things about fishes at a distance, which we have no chance of observing, but little about those at home." If you will grant me a few minutes I would like to say a few words concerning some which are very much at home, both as far as you are concerned and in their relationship to the topics under discussion. Phosphorescent fishes occur in most latitudes, and for proof that electrical fishes occur in British waters, we have only to recall our common Skate. In dealing with the

electrical apparatus, we saw that with the exception of the Nile fish the organ is muscular in nature, whereas in that creature it is glandular. It is precisely in view of this difference that some interesting investigations now being made on the West Coast of Scotland come to our assistance. Professor Weymouth Reid is there instituting an enquiry into the electro-motive properties of the skin of the common eel. We have long known that the functions of the skin of fish and certain other animals are accompanied by electrical changes; and Professor Reid is deducing good evidence to show that the electrical discharge thrown off by the skin of the common eel (i.e. the electro-motive force of its "current of rest") is directly related to the secretory activity of its gland-cells. I cannot help thinking that his investigation, now being performed on one of the commonest of common fish, will ultimately throw a flood of light on the origin of the glandular type of electrical organ. Applying Dohrn's principle once more, in the muscular form of electical organ we are dealing with conditions under which the energy of a muscular contraction becomes converted into that of an electrical discharge, and in the apparently glandular form with the probable conversion of that of a glandular secretion to the same purpose.

Returning finally to migration and the accessory organs of respiration, we know that our common eels are in the habit of migrating from river to pond, and some of us may have captured them in the act of so doing. The gill-cover of the eel is, as it were, cemented to its head, in such a way that instead of the wide opening of communication between the gill-chamber and the surrounding water so familiar in our commoner fishes, there is but a small slit situated relatively high up. The conditions are such that even when the mouth is open a considerable quantity of water may be retained in the gill-chamber, sufficient, apparently, to effect the function of respiration.

Coming to the two special conditions of adaptation which remain, viz: those of respiration by the tail an the accessory pharyngeal sac, our whole consideration comes to a focus in one of the most familiar fish of our coast on the one hand, and in a fish particularly familiar on the Cornish Coast on the other. The common Blenny is famous for its habit of leaving the water; but it is not generally known that if it be confined in a vessel of water containing stones or other objects favourable to its obtaining access to the surface, the creature, when it settles down to its new existence, may put its head out and remain with its tail immersed, in the manner of the Periophthalmus. This being so, the solution of one of our two remaining problems lies, in all probability, in the study of one of our commonest fishes. Our common Loaches are said to rise to the surface to gulp in air, like the Callichthys, and the habit of thus "rising" is a well-known one to anglers of our familiar coarse fish. The probability that a deep significance may underlie it appears very great from a discovery which we owe to Dr. Sidney Ringer—that the death of a fish by confinement in distilled water, is not so much due to the abstraction of Oxygen as to that of certain chemical salts in solution.

The pharyngeal sac occurs in its simplest known form in the common Shad, and in its next highly modified one in the Pilchard. We who are interested in the scientific aspects of ichthyology, want very much to know the functions of this organ in the herrings and their allies; and if it be with it as with many other organs of the animal body, that the elucidation of its primary significance is to be sought in the study of its simplest forms, the homely pilchard and shad must occupy an elevated position. I trust to have not merely shown that these important questions find their focus in the study of fishes around us, but that a most interesting problem probably awaits its solution in the Cornish Pilchard. And here I would urge

a caution against a great error of our times. In these days of competition, when we younger men are well-nigh threatening each other with violence in our desire to "get on" as we term it, there is a tendency to travel afield in search of material for work. Experience shows that if you but take up the humblest creature under your feet, there is everything there to be enquired into if you aspire to honest labor; and if I have done nothing more than show that one of the most interesting questions engrossing the attention of the physiological ichthyologist awaits its solution to-day at the hands of Cornishmen, who are in daily contact with the common pilchard and the shad, I flatter myself I shall not have not laboured in vain.

Of most of those 8,000 odd species of fish of which I spoke at the commencement of my lecture, we know but little except that they exist. The field of enquiry is therefore a vast one; the workers are few, and what we do-day want is the enlistment of recruits, qualified by nature to take up the task and reveal for us the workings of her laws. The attitude of such men is best expressed in the wonderful words of Sir Thomas Brown, who, in his Religio Medici says:—"The world was made to be inhab-"ited by beasts; but studied and contemplated by man. "'Tis the debt of our reason we owe unto God, and the "homage we pay for not being beasts.......The wisdom of "God receives small homage from those vulgar heads "which rudely stare about, and, with a gross rusticity, "admire His works. They highly magnify Him, whose "judicious enquiry into His Acts, and deliberate research "into His creatures, return the duty of a devout and learned "admiration."

Mr. MATTHIAS DUNN remarked that in 1855 this country was visited by a very severe winter, and all along the coast from Dover to Cornwall some thousands of tons of Conger died. The cold water seemed to have affected

them, and they were picked up and carried ashore 20 and 30 tons at a time. In 1870 there was a very severe east wind, which brought down a large quantity of ice, and millions—he believed he might say thousands of millions of pilchards died as the result. In 1870 a small fish called the Boar fish, became very plentiful on the Cornish coast, and lived there for seven or eight years. In 1879 a violent east wind came upon the coast, and these fish entirely died out; since then none had been seen in the shallow waters.

The Lecturer was accorded a vote of thanks.

LECTURE 2.

(Delivered on Wednesday, July 26th, 1893.)

NATURAL HISTORY

OF

CERTAIN SEA FISHES,

BY

J. T. CUNNINGHAM, Esq., M.A.,

The Marine Biological Association.

Chairman—Howard Fox, Esq.

NATURAL HISTORY OF CERTAIN SEA FISHES.

The Chairman said it was well known that some of their industries in Cornwall were gradually waning. They had therefore to look round and see in what manner they could maintain their material prosperity in the fishing villages along their 180 miles of coast. If they could get a larger amount of wealth out of the sea, they would increase their food supply, besides adding to the material wealth of their own county. Thirty years ago when on a visit to Galway, he visited a salmon culture establishment, purchased some years previously for about £8,000; £5,000 was afterwards laid out in making an artificial lake, with the result that in the second year after the application of scientific knowledge in the protection of the salmon fishery, a return of £5,000 per annum was made, and he believed that Galway fishery had been equally remunerative from that day to the present. Such experiments could not, perhaps, be carried on in Cornwall through private enterprise, as it was more particularly a matter for the community at large, and in that way he thought the Fisheries Exhibition might eventually be able to render extremely important help.

The Lecturer said, it is exactly ten years since the great Fisheries Exhibition held in London in 1883, and it is very interesting to compare the state of knowledge concerning our most important sea fishes which was represented in the literature and records of that exhibition with that which can be

brought forward at the Cornish Exhibition. It is satisfactory to find that important progress has been made. Indeed it would be strange if we had no progress to report, considering the labour and expense which have been devoted to the investigation of the subject in these ten years. The Fishery Board for Scotland has poured out money like water in its scientific researches. In England the Marine Biological Association has steadily pursued the investigation, and in Ireland much valuable information was gathered, analysed and recorded by a survey of the fishery grounds on the west coast, carried out by the Royal Dublin Society in 1890 and 1891.

Before the exhibition of 1883 it was known that the Herring deposited its spawn on the sea bottom on rough or gravelly hard ground, and between 1860 and 1870 it was discovered by Professor Sars in Norway that the eggs of the Cod and Mackerel floated about separately in the sea. It was soon found that the Cod and Mackerel were by no means exceptional in this respect, additions were constantly being made to the list of sea fishes which had floating eggs, and the flat fishes such as the Flounder and Plaice, were found to be among the number. The eggs of the Flounder were first examined in Sweden in 1868, and several flat fishes were found to have floating eggs in America from 1878 to 1882. In 1881 the eggs of the Flounder and Plaice were studied in Germany, but in this country they had not been studied up to the London Exhibition of 1883. There is not much on the natural history of sea fishes in the literature of that exhibition, but there is an essay on the history of the Sole in which it is pointed out that nothing was known of the spawning and growth of that fish, and it could only be conjectured that it went through changes similar to those of other flat fishes. I will now give you some account of what is known of the history of some of our bottom fishes, especially the flat fishes, at the present time.

The eggs of the Flounder, Plaice, Merry Sole and Dab are all exactly like those of the Cod, Haddock and Whiting. The only differences among them that can be detected are differences of size. After a short period, during which the little fish developes within the egg, the egg hatches and the young fish is set free. The little fish at this stage is very different from its parent, and very much like other newly hatched fishes.

For the first few weeks of its life the flat fish swims upright in the water. In the ordinary fish the conversion of this undeveloped little creature into a perfect fish like its parent is due to the formation of the bones and fins and of the scales. The little baby fish is transparent, the perfect fish is not. The fins are formed by the growth of the rods of bone which support them. All the while the change is going on the ordinary fish, such as the Whiting for instance, swims about in the same position in the water. But in the Flounder a greater change takes place; while the bones and fins are developing the eye of the left side gradually moves up out of its first position on to the top of the head, and then round on to the right side and the young Flounder goes to the bottom and rests most of its time on the left side.

We must now consider the time required for these changes and the places where the young fish are to be found. In most cases each kind of fish spawns during only one part of the year, during a period which is about three months in length or a little longer. It is difficult to fix exactly the beginning and the end of the spawning period, as to do so it would be necessary to examine the fish daily for some months. But it has been done in most cases with sufficient certainty. The period of spawning is a little different in different districts. On this coast the Plaice spawns in January and February, perhaps begins in December and it has finished before the end of March. In February and March several fish are found to begin to spawn such as the

Flounder, the Dab, the Whiting and others. The Merry Sole spawns in March, April and May, and the Sole at the same time. The Turbot and Brill are somewhat later, chiefly in May and June. The Mackerel also spawns in May and June. Very few kinds of fish spawn in the latter half of the year. The Herring on our coast spawns only from January to March, but on other parts of the British coast it has two spawning periods, one in the beginning of the year, January to March, one late in the summer about August and September, the periods varying somewhat in different districts.

The eggs of sea fishes are usually very small, and sometimes the larger fish produce the smaller eggs. The egg of the Whiting is one-twentieth of an inch in diameter, twenty eggs placed in a row would cover an inch. The eggs of the Cod are a little larger, and of the Gurnard larger still. The eggs of the Plaice are nearly one-twelfth inch in diameter; those of the Flounder much smaller, one twenty-fifth inch; of the Dab, one-thirtieth. The eggs of the Merry Sole and of the Sole are between those of the Flounder and Plaice in size.

The eggs do not usually take long to hatch, the time differs in different kinds of fish, and is quicker when the water is warmer. It varies from two or three days to as many weeks. In the Sole it is about ten days. The next question is how long does it take for the newly hatched fish to grow into the fully developed condition, when it is like its parent but very much smaller. This period is about two months. The new fish of the year are found every season regularly at about the same time. For instance, in March and April the young Plaice, Flounders, and Soles are found in certain places on the shore, in the pools and channels left by the ebb tide. These fish are in the last stages of their development to the perfect condition, some having just reached it, and they begin to appear about six weeks or two months after the commencement of the spawning period of

their kind. The Flounder is half-an-inch long when it reaches the perfect condition, the Sole about the same, and the Plaice a little larger. From the end of May to the beginning of August the corresponding stages of the Brill and Turbot appear, but strange to say they are not commonly found on the ground between tide marks, but swimming at the surface of the water in harbours. They are much larger than the flounder and sole before they reach the perfect condition, and also not transparent but opaque and coloured, so that they are easily seen in the water when it is calm. These young fish are about an inch long or a little more, the Brill being somewhat smaller than the Turbot. In this condition the right eye is on the edge of the head or near it on the right side, or just past it on the left. After this stage they are not seen at the surface, but go to the bottom like the Sole or Plaice. Young Dab at the stage in question are also found near shore. But other flat fishes have never been found near the shore at this age and size. For instance, the Merry Sole, the Thick Back, and the Megrim, the yonng of these kinds have not been found on English coasts at this particular stage, because not sufficient search for them has been made, but off the west coast of Ireland a few were taken in deep water in the Fisheries Survey of 1890 and 1891. It seems a puzzling thing that the young of some kinds of flat fishes should come to shore and not others, but it must be remembered that the parents of those which do not come to the shore are themselves usually found at greater distance from the coast, and this may be the reason. The Flounder like the Sprat is practically a fish of estuaries and shallows except when it is spawning. Flounders can be taken in the Truro river all the year round, but go out in a trawler some miles from land and you will not see a Flounder caught except in the first four months of the year, and then they will be full of roe. Plaice also are not found far from shore except on shallow banks such as the Dogger in the North Sea. Soles and Turbot also spawn not far from

land. This is one of the subjects which requires further investigation, and which can only be investigated in a vessel under the control of naturalists and devoted to the purpose.

Now let us turn to the round fishes and we shall find similar differences. Whiting, Cod, Pollack, Pout, and Poor Cod, when very young, are most abundant near shore. Of young Hake and Ling we do not know much at present, but Hake of 1¼ to 1½ inches were taken on the west coast of Ireland in 80 fathoms. Young Haddock have been found in the north sea only on the trawling grounds at depths of 16 fathoms to 30 fathoms, and have never been taken near shore. Mr. Holt, a naturalist of our staff, stationed at Grimsby, has taken numbers from 2 to 4 inches long in September on the fishing banks of the North Sea. Young Whiting and Cod are found out on these banks too, as well as in the shore waters. Young Pollack have been found only near shore. The young of the Grey Gurnard have been found both in waters of 3 to 10 fathoms in depth, and at various depths up to 45 fathoms.

The next important problem to be considered is how long these little fish take to grow to their full size, and at what age and what size they begin to spawn themselves. This appears at first a very difficult problem, and so it is, but it is not impossible to get some evidence about it. One way to attack it is to take a number of fish whose age we know, and grow them in an aquarium. This is what I have done at Plymouth. If we take the smallest specimens of fish, Flounder, Plaice, Turbot, or any other kind which are to be found during the spawning season, it is clear that they must have come from the previous spawning season and must be nearly a year old. For instance, in May at Plymouth, I have taken Soles 6½ to 8 inches long, and not capable of spawning; these must have come from the spawn shed the previous year. Much important evidence on this question of growth has been got by considering the size and condition of the small fish taken in various modes of fishing.

For instance, the shrimpers take usually small fish with the shrimps, and in some localities they take a very large number. Among these fish in April, Flounders are taken from 2½ to 7½ inches in length. We know that these have not grown to that size from eggs shed in March, because the earliest Flounders of the year are only just completing their transformation in April, so that it is perfectly certain that there are a large number of flounders in the sea which are the same size, and have the same differences in size as those which were 1 year old in my aquarium, and these fish are not spawning although taken in the spawning season.

It is clear that if every Flounder or other fish which survived to one year of age, become mature at that age, began to breed, then when the spawning season arrived there would be no immature fish. We can easily see by looking at the roe of a fish in the spawning season whether it will spawn that season, because the changes which precede spawning, the ripening of the roe, begin several months before hand. Now a large proportion of fish taken in the spawning season are not mature, cannot spawn that season, although we are certain that they are a year old. From the fact that they are so abundant, and from my observations in the aquarium, it may be considered certain that no flat fish spawns when it is one year old.

Now let us pass to the second year. I kept my flounders alive, I did not kill them when I measured them in 1891. In February, 1892, when they were two years old I measured them again. There were 90 altogether, in length from 3 inches to 10½ inches, a most remarkable difference in size. Of these only 17 were ripe or nearly ripe, nearly ready to spawn, and so far as I could observe no others spawned that season. I killed some and I know that these were not mature. So that it is at any rate certain that a Flounder may in captivity spawn when it is two years old, but not all at that age do spawn. There is good reason to believe that the same statement applies to Flounders and

other fishes in the sea. I wish to ask your attention to the important and striking fact that my results concerning the Flounder agree exactly with the conclusions reached long ago from observations on the life of the salmon. It is known that the eggs of the salmon are hatched in spring, and that when they get beyond the larval or imperfect condition they live in the rivers as little fish with cross stripes known as parrs. It has been proved that when one year old some of the parrs go down to the sea as smolt in spring, and return to spawn in the autumn as grilse. Then these grilse spawn the second winter after they are hatched, and not before, while a large proportion of smolt do not go to sea until they are 2 years old, and do not produce offspring until they are 3 years.

After this brief sketch of the main facts in the life history of these food fishes which live on or near the sea bottom, I want to ask you to follow me in an attempt to consider what we can reasonably hope to do with the object of preventing the diminution, or producing an actual increase in the supply of these fish. The best way it seems to me to look at this question is to treat it as our Registrars treat human populations, at any moment there are a certain number of fish of a certain kind on our fishing grounds, and the number may increase, diminish, or remain the same. It is a matter of birth-rate and death-rate. It has been frequently argued that because fish in their breeding seasons deposit such a large number of eggs, and breed such a large number of young, that in spite of the destruction going on by means of steam trawlers and other destructive agencies, the existing supply can never be diminished. The fecundity of fishes is undoubtedly extremely great, and supposing a large proportion of the eggs grew into perfect fish, then it would not matter how many of the old ones were destroyed if the others lived. But not nearly all the eggs of one fish grow into perfect fish or even into fish at all. If all the ova deposited were hatched, and all the young reached the

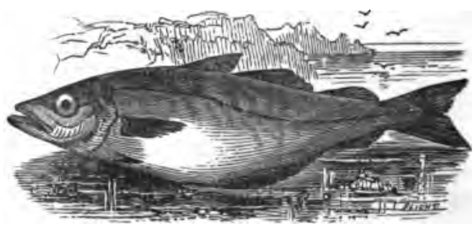
mature age, we need then have no fears as to any decrease or scarcity of fish. That, however, as I have before stated, is not the case. In the first place a large number of fish, especially the herrings and pilchards, consume a large quantity of the eggs. When the young fish are hatched they also have many enemies, including the fishermen, who frequently catch large numbers of immature fish in their nets, which, when caught, are no of use for the table. The question then arises what can be done in regard to artificial hatching. Artificial hatching is, as many of you are well aware possible and if it can be successfully carried out, on a large scale it will be possible to increase the fish supply without having recourse to close seasons. But artificial hatching is attended by many difficulties. No doubt more fish can be hatched in artificial hatcheries under careful attention and proper conditions than if the eggs are left in their natural habitat. I should point out that as far as valuable fish are concerned we may consider the population of the fish as the number of those that are marketable. Supposing a plaice is not much use for the table until it is 8 inches long, what we have to do is to increase the number of fish above that length. I will conclude simply by reminding you of the extremely important and interesting way in which an exhibition of this kind helps in promoting the study of fishery problems and the solution of them. A great deal of interesting knowledge has been discovered since the International Fisheries Exhibition in London in 1883, and this knowledge resulted, to a great extent, from the holding of that exhibition. Of course the Cornwall Fisheries Exhibition, now being held at Truro, is a county effort and cannot be expected to have such large results as the International Exhibition. But I think it may reasonably be expected that from the Cornwall Fisheries Exhibition, there will result a similar kind of benefit for the county to that which was effected for the whole country through the holding of the International Exhibition.

The Rev. A. R. Tomlinson, St. Michael Penkivel, in moving a vote of thanks to Mr. Cunningham for his most interesting and lucid lecture said, that the material was of such an interesting and comprehensive character that it ought not to be compressed into one discourse, but that Mr. Cunningham should give a series of lectures on the subject.

Mr. G. H. Fox, Falmouth, in seconding said, the thanks of all Cornishmen were due to Mr. Cunningham for the enlightenment he was spreading throughout the country in regard to the fisheries.

The Chairman concurred with the remarks of the Rev. A. R. Tomlinson, and on putting the motion to the meeting it was carried unanimously.

Mr. Cunningham briefly acknowledged the compliment, and proposed a vote at thanks to Mr. Howard Fox for presiding, which was heartily carried.



LECTURE 3.

(Delivered on Friday, July 28th, 1893.)

The Protection and Preservation

OF THE

CORNISH SALMONIDÆ,

BY

ALFRED BURDEN, ESQ.,

("NOSS MAYO.")

Chairman:

THE REV. ST. AUBYN H. MOLESWORTH ST. AUBYN.

THE PROTECTION AND PRESERVATION OF THE CORNISH SALMONIDÆ.

The Lecturer said:—It has struck me more than once that a lecture given on a subject which in some degree is familiar to everybody, requires a considerable amount of attractiveness to compensate for the lack of originality, and therefore the lecturer who cannot produce, or who does not feel it necessary to his ends to produce, extra attractiveness by means of pictures, diagrams, &c., is, to commence with, severely handicapped. But a fisherman is credited with being an adept at resource (in fishing, not in lecturing), and would naturally consider that to complete the mixture which he offers his audience, the ingredients should be principally a compound of personal experience, instead of tough strings of abstruse theory, with a spice of fisherman's fortitude in the make-up, and, perhaps, an additional flavouring of fisherman's assumption used in any part of the lecture which may be debateable; that is to say a fairly good faculty for inventing an opinion which is not likely to be controverted. That's what a great many people think fishing debate means. By the riverside the other day, I told a friend I was going to lecture on the Cornish Salmonidæ, but I was afraid my remarks would necessarily contain much that was already known. "Well," said he, "isn't there a great deal that neither you, nor I, nor your listeners know of about our fresh water fish?" I acknowledged there was. "Then lecture on that" said he. But debateable matter is not pleasant to offer, nor to receive, and as little of it as possible shall creep into what

I have to say. There is a truism which says, where there is no knowledge whatever of a subject by an audience, there can be little or no corresponding interest imparted by the lecturer; and accepting that, it may be said only those who fish, who have fished, who intend to fish, or who like fish, care anything about lectures on fish.

Has it ever struck you how poor in expression our language is? "Fisherman—one who catches fish." That is to say, he may be anything, from a hauler of crabpots to a sniggler for eels, from a trawlerman to a fly fisher. 'Going fishing' is vastly different in its results to going out to catch fish. The only synonymous application I know of, is that fish stories (freshwater fish stories) are almost invariably fishy. But this is etymology not ichthyology, so I will begin my lecture.

The fish which we are proud to say are indigenous to our Cornish, and indeed, generally speaking to our south-western streams, may be arranged under the heads of migratory, and non-migratory—fish which make periodical immigrations from the sea, and those which are continually with us.

Non-Migratory Fish.

Arranging the non-migratory fish in the order of their value, we first have the common trout, *salmo fario*, called in Scotland the burn trout, from the burns or narrow valleys in which they are found, or yellow trout; but identically the same fish which we have in our Cornish streams. These are, par excellence, the fish of our rivers which flourish so abundantly, are sought after so greedily, and provide such indescribably delightful food. Besides these, there are the coarser fish,—eels, esteemed everywhere more highly than in Cornwall; dace, which are unfortunately increasing in the Tamar and consequently in the Inney, and which as sport providers, and articles of food, are very second-rate compared with trout; flounders, which are not so plentiful as they were twenty years ago,

and a naturalised fish, not a hybrid, but a domesticated species of the salmon or sea trout, most probably of the latter, which has apparently relinquished the instinctive intention of going back to sea, and has lived, without breeding, with the common trout. Then there are the imported Loch Levens, which have been used for stocking, where the supply of common and indigenous trout is scarce. Across the borders of the county, in the Erme, where the pollution has seriously diminished the trout, Loch Levens have been introduced, and have thriven very well, some of them reaching to three and four pounds in weight. Where the scarcity of trout is very marked, it is a capital plan to introduce Loch Levens, but they do not improve a river which is stocked naturally with an average amount of our own trout. Of each of these species, except the trout, it is perhaps unnecessary to enlarge, but the naturalised fish which I spoke of just now, calls for just a passing attention, as it is one of thosé doubtful creatures which cause very pardonable heart flutterings on the part of the captor, and which makes him feel anything but happy when the water bailiff comes by to enquire suavely about the sport, the license, and the fish. That there are considerable quntities of these fish, I am from personal experience able to say is unquestionable, and rarely, indeed, is a basket of trout, taken from a stream which contains migratory fish, minus a specimen. This fish, called locally a "streamer," and which I believe has not been noticed hitherto in any piscatorial work, is exactly the shape of a trout of its size, but it differs in colour and spots. It retains in a great measure the migratory fish markings, excepting that it has lost the blue bars, has fairly bright pink spots which die out with age, has no yellow tingeing, and has little or no colour on the dorsal fin. It is found often very high up in the moorland streams, where it has gone probably with the trout which were on their way to spawning grounds. After visiting these higher waters, it is probable that the desire to go to

sea leaves them, or the attempt to get there is futile, and the fish becomes naturalised. Then, again, the flavour is pronouncedly different. Being by origin a migratory fish, it does not develop the tastiness of a common trout, and is far inferior to those smolts which have made a short journey into salt water, and again returned, as in the case of the whiting or herling of the Solway rivers. In fact, they have nothing in common. The Cornish fish is comparatively yielding when hooked, the Borderland fish game as anything that swims. The former's flesh is vapid and almost tasteless, the latter's rich in flavour as a sea trout, without the colouring which is the distinguishing mark of maturity. Of course, I shall be met with Mr. Cholmondeley Pennell's assertion, that parr or smolts do not go back to the sea sometimes for two or three years, and that there are phases in its development which may account for the change in markings. All this I grant, but I contend that some do not go back to sea at all, as I have caught them weighing nearly a pound with the exact markings of the two or three ounce ones, not a yellow or black spot on them, and with flesh singularly unlike the trout in flavour or in colour. Between this fish, the Cornish fish, as has already been mentioned, and the sea-going parr in fresh condition, there is therefore a very visible distinction, and although I am hazarding an opinion, I should say they *are* not or should not be, legally forbidden fruit to the licensed trout fisher. No fisherman who deserves the name, mistakes a real sea-going parr for the fish which has been so imperfectly described; and if he did, the capture in either case is not so vast as to make its retention a vital matter. Still, it makes up the number, which is what I am sorry to say many south-western fishermen go for.

I remember dining at a hotel at some distance from here, not in Cornwall, and asking for some trout. They were very small—very—but the waiter acting under orders probably, kindly reminded me that little fish were sweet

—a strikingly original statement. Now I do not object to little trout, for they are sweet, but these were very obviously Salmon parr, and I said so, and the waiter was of course very much surprised. However, cooked fish are useless returned to the water, and so in an indefinable sense, I broke the law, did the next best thing to returning them, and ate them : and very nice they were.

The common trout, common only because it is *the* fish which finds everything it wants in our rivers and which in spite of continuously altered legislation still monopolises the water, the fish which gives sport to so many, and health and even life to not a few : the fish which, if its rapidly improving education says anything, must be the most intelligent fish that swims, is the fish we so urgently want to preserve. It is thousands of times more ornamental in ornamental water than that king of laziness, the golden carp, and it lives just as gaily, darts about as rapidly, and feeds just as freely in the humblest and most forsaken streamlet, as it does in the foliage bedecked, and gorgeously constructed ponds, the artificial cascades, and the fathomless and mountain-bound lakes. To hundreds and hundreds of people the happiness of a whole year is concentrated into a couple of short weeks' acquaintance with these delightful little black and gold creatures, which give them the purest and the most wholesome pastime. In Cornwall and Devon trout are at home. *To* Cornwall and Devon come the hundreds yearly to participate in the native pleasures which the natives are so ready to offer, and so proud to exhibit. It may be questioned as to whether it is quite in the line of my sea-fishing congeners, whose interests by this exhibition are so admirably thought of, to consider the pursuit of trout, or trout culture, in the light of an industry. But most emphatically I do consider it so. Ask the hotel-keepers or lodging-house keepers by the riverside, and those who indirectly benefit by them, whether it is beyond the reasonable bounds of ordinary opinion, to call the sport of trout fishing anything less than

a most prosperous and steadily improving industry. Where is there a hotel or lodging house within fair distance of a river which cannot furnish a trout breakfast during the season? Bear in mind, streams are not exclusively fished by those who pay heavily for the sport, and who too often get very little in return for it. The more artful and more experienced brother of the rod gets his living out of them, and may he continue to do so, if only to satisfy those peculiar and unfortunate people who say trout are "sent for food." As an article of food it is acknowledged that there is scarcely a more toothsome delicacy than a trout. But unlike the migratory fish, trout breed, feed, and live, within the property of private individuals, and although it is impossible to consider the production of trout, by estimating this production at any pecuniary value, so owing to the comparative scarcity of these fish and their size, it is difficult to imagine that tront should to any extensive degree, be a recognised commodity, with a fixed saleable price. Where, therefore, the riparian owner waives his right to the fish he has the prior claim to, and permits the public to enjoy what he might if he choose, reserve to himself, the onus of preserving these fish belongs undoubtedly to those to whom the right is given. Professional fishermen in open waters still get a big share of the trout, and, as I have said, nobody who is staying in a town adjacent to a trout stream need go long without a meal. Here, then, in a greater degree than is generally known, there is an industry which gives no trifling help to many Cornishmen.

A week or two ago it was my extreme pleasure to visit a gentleman in this county, and to see the exquisite improvements he had made for the benefit of the fish I am wearying you by talking of. A moorland stream found its way into his property, and this moorland stream held trout. To give them more room, better food, and complete protection was his fixed determination. And although the effort required years to complete, he has made, or improved,

a succession of ponds which, without considering their picturesque beauty, hold trout enough to satisfy the most gourmand sportsman that ever lived. Trout, too, that are so well cared for, that they have grown to double and treble the average size, they would have attained in the original stream. This is not so much the result of unmolested age as the scope of freedom which each fish enjoys. Then, again, the stream which issues from these ponds, and which flows through the centre of the grounds has been so much improved by introducing steps of granite boulders, hundreds and hundreds of tons of which have been so utilized, that fish revel in the deep pools, where they are able to defy droughts, fishermen revel in the sport which they get, and the whole park is, not only on the word of a fisherman, but by general consent improved beyond estimation. Besides this, recognising the difficulty of confining trout to a particular neighbourhood, the open water above and below is unquestionably indebted to this nursery for its excellent supply. "I do not fish now," says the generous owner, "but I do like to feel that my friends can get sport, and the more they get, the better I am pleased."

Was there no industry in the preparation of a fishery like this at Trebartha, one of many similar efforts in this county? Can you pit against it the joint adventures of a couple or three men, who, because a little money was temporarily available, could, in a single day, by the effusion of poisonous mineral water, destroy all the labours of a couple or three generations, and kill all the fish? It is too lamentable a catastrophe to even dream of. Those gentlemen who argue that the natural industries of a district are estimated by the amount of energy and manual labour which are expended on them, should therefore consider whether after all, the preservation of trout may not be classed an industry of the most generous type.

Two or three matters in regard to the construction of fisheries like these might, *en passant*, be noticed. It is necessary that the feeding stream should first of all be most carefully considered, as those ponds into which the rush of water from the feeder is felt for the greatest distance are the likeliest to hold most trout. In the succession of ponds, the streams which flows from the first to the second, and into each succeeding pond, should be met a few feet away from the bottom by an artificially constructed island, a yard or two distant from the influx of the water, which water should flow riverlike round it into the pond. This plan, in the case of extreme drought during the spawning season, September, October, and November, would offer available spawning grounds to the trout which are debarred from entering the higher ponds, and getting from thence into the primary feeders. The particular places, as will be told you by the gentlemen who make the breeding of trout an especial study, which trout look out for for depositing the ova, are the pebbly beds, which by the action of the water are kept clear of weeds, are if possible open to the sun, and are in depth, varying from six to eighteen inches. Ponds do not contain such spots, hence the necessity of good feeders, the beds of which should, during the early summer be carefully attended to. Besides this, it is necessary to fence the feeder well to prevent ornamental or other birds, such as ducks and swans from entering them, as they are most wilful offenders in the matter of destruction of ova.

And now a word to the legal rights of riparian owners. A great outcry is occasionally heard, and most frequently I am sorry to say, from those who catch most fish, and have not the least possible interest in the land, a cry of complaint against those who have the control of streams in which there are fish, and who take commendable means to keep their water well stocked. The law is tolerably clear on the point. A person who owns land on one side of the river, includes in his property one half of

the bed of that river, so that he can take means to restrain anyone from wading on the bed of his half. If he own the both sides, he owns the whole of the bed. Granting that the water is common to the community, for purposes which may be for the good of the community or a section of it, it cannot be conceded for one moment that the community has therefore a right to the trout which are in it, otherwise that same community might destroy them *ad libitum*; but as these fish feed principally upon what the same beds produce, or the land on each side produces, it is clear they must primarily, although perhaps not legally, if they belong to anybody at all, belong to the owner or owners of the adjoining land. And such is the view the legislature evidently has of it, and it supports this view by sanctioning bye-laws formed for the purpose of making it illegal to take trout in any other way than that which is settled by the local bodies. Moreover, hard as it may seem, if a riparian owner holds one side of the water, and desires strictly to preserve his fishing, although he cannot claim any proportion of the fish in the stream, he can forbid a line to be cast on his half by any person who may have the right to fish on the other side. So that it is quite possible for one owner who detests trout and trout fishers to actually net his half, and effectively net it too, while the other is doing his utmost to accumulate as many fish as he can—as absurd a picture as can well be imagined. And here I should like to repeat a remark I made just now. Where, therefore, the riparian owner waives his right to the fish, he has the prior claim to, and permits the public to enjoy what he might if he choose reserve to himself, the onus of preserving these fish belongs undoubtedly to those to whom the right is given. Three-fourths of all the fishable water in Cornwall and Devon are so open to the public, and the public by their representatives should in common gratitude mark their appreciation of this acquisition by the better preservation of the fish in all those streams which are now utterly neglected. There need not

be an outlay to accomplish this. Every policeman should be ordered to demand a license from any person he sees fishing in a stream under the control of conservators. Those who take fish for sport will pay; those who take them in buckets will not; and the double advantage will be secured of adding substantially to the revenue, and getting rid of avaricious enemies to the protection of fish. There are very many such neglected streams, and on these streams the question "How to catch trout *with* rod and line" is rarely asked. It is "How to catch most *without*." These remarks are strong, but true: and if they show a remedy for an evil, you will certainly want to know what the evil is.

Migratory Fish—Salmon (*S. Salar*).

And now it is quite time that I should begin to speak of the other class, the migratory *Salmonidæ*, the salmon and peal, and what other species, according to the opinions of some of our west country authorities frequent our waters. You all know that the periods of immigration of both the salar and the trutta differ, as do also the periods of spawning, but the same habits pertain as nearly as possible to both. Salmon spawn generally throughout the country in November, December, and January, but in the Camel and Fowey—and when I speak of the Camel and Fowey, I mean the whole of the rivers of the county of Cornwall, but especially these two, as they are the principal salmon streams—in the Camel and Fowey, it has been recognised, and rightly too, that the ascent into fresh water is quite a month later than in the majority of other streams, the greatest quantities of salmon travelling in November and December. The Tamar is earlier; and the reason for this is most likely to be found in the fact that the temperature of the water is higher. The Tamar has, from its source to its mouth, a fall, which, compared with the size of the river, is much less than either the Camel or the Fowey has. The progress of the Tamar is therefore much slower, and the development of heat more certain.

As an illustration of the fact that waters of lower temperature receive salmon later, it may be mentioned that in the Inney, a Cornish tributary of the Tamar, which rises in the high moorlands, and has a rapid fall, salmon are very rarely, if ever, seen by trout fishermen, because they do not enter the river until the trout season is past. But they do enter this stream, and run up, and especially have they done so during the past two seasons, since the improvement of the weir on the Tamar, because parr are often caught in the Inney, and in fact are exceedingly plentiful, more plentiful than the riparian owners wish. Now, the Camel and the Fowey both rise in the highest parts of Cornwall, and having a quick passage to the sea, the heat development is less rapid, and the temperature considerably lower. I mention this because, as you all know, we enjoy in the extreme south-west the extraordinary privilege of being able to take salmon a month later than is permitted in most other rivers, and those who know our salmon streams, will, from their own personal observations of salmon progress, allow that it is only reasonable.

From the time of entering the river, the phases of a salmon's existence are peculiarly interesting. Its one object is to get into the shallower and quieter waters higher up, for the purpose of depositing its ova, and although some writers assume that a deposit, a valueless deposit may take place in the sea, it is quite impossible to accept this as anything more than the wildest assumption, because I believe we never find a fresh running fish which is completely barren. The salmon, exactly like the trout, requires for its purposes, comparatively shallow, running, fresh water, and a pebbly bed, and when it is once located as its instinctive tastes demand, the conjunctive deposit commences ; and the ova and the milt are not shed into a pit as is popularly supposed, but in lines. The vivification occurs only after the conjoint deposit, and the milt is as regularly shed by the male as a deposit is made by the female. My assertions are made from actual observation.

The joint deposits occur at intervals of ten minutes or a quarter of an hour, and last from 30 to 50 hours, according to the size of the fish. The deposits are then covered by the female, the fish leave their quarters and each other, and the whole process of hatching is completely independent of fish agency. However, fish development is not the line marked out for me, and consequently, I will, as briefly as possible, say only as much of the ingress and egress of salmon as will help me to describe the means which are taken for their protection and their increase as a food supply. After spawning, salmon, and for that matter peal, are called kelts or spent fish, are unfit for food, and are not permitted to be taken. They then, as soon as they recover strength, make their way back to sea. If their movements are slow, owing to drought, as has been the case now for the second year in succession, they acquire strength, and become the most perfect pests, and the most malignant thieves and cannibals that it is possible to conceive. Where the mills absorb a considerable quantity of water from the main stream, and obstructions, natural and artificial, are unusually prevalent, kelts are absolutely waterbound, and recognising the fact that they cannot get back to sea without the providential assistance of a freshet, I say they most certainly should be removed by netting, and taken to a part of the river from whence the egress is a matter of no difficulty. This resort has been adopted by the Camel Conservators during the past few months, and much to their credit, although, perhaps, on another occasion they will see the necessity of taking the fish they net down below the last outlet from mills. And I make this suggestion because kelts are disinclined or unable to take any trouble going back, and as the greatest bulk of water in an ordinary season is that which is absorbed by the mills, the mill-stream is the only apparent way to sea. Going over a mill-wheel may be expeditious, but it is not exactly conducive to the preservation of the fish,

This year (1893) the season for progressing, or fresh running fish, has been the most adverse up to now, I ever remember. In two instances, just beyond the borders of the county, the Yealm and the Erme, both capital streams for salmon and peal, for many weeks *not a drop of water* has flowed over the bed of the river between the intake of a mill and its outlet. The spawning beds are above the mill and its water. Where do these fish deposit? or perhaps I may ask where are they deposited? An Englishman is by foreigners supposed to be one of the most taciturn of the human race, and even Englishmen will acknowledge that this chracteristic is never better illustrated than when the question, 'Where are they deposited?' is urged. Provision for the safety of fish during drought should not be left to the inclinations of local bodies, however good they may be, but should be made an imperial matter. A kelt which gets to sea in the early spring months returns to fresh water in the autumn or winter, from fifteen to thirty per cent. heavier, and therefore it is very evident that there would be a great increase in the food supply if more stringent measures were compelled to be taken by local bodies to help waterbound kelts back to sea. In fact, if the County Councils of the two western counties acting together, were to appoint a local inspector, who would work on lines suggested by the Chief Inspector of Fisheries, and who would assist the conservators, and advise them in all matters relating to the welfare of migratory and other fish, there is no question that the outlay would almost pay for itself in the increase of the food supply.

In Mr. Berrington's lately issued report of the salmon fisheries, he attributes the decreased take of salmon in the smaller rivers to the weather, and expresses a fear that another cause is the defective management of the less important districts. Where the permanent salmon fishing interests are large, they hold their own, but where they are not (and this applies to the Cornish streams) the carry-

ing out of the principles embodied in the Salmon Fishery Acts are often little attended to, and the ultimate consequence cannot fail to be a reduction of the supply of salmon for the markets. Are the Conservators unable or unwilling to improve the preservation of the *Salmonidæ*? Perhaps both. If they are unwilling, they can be made more assiduous. If they are unable, and this may very probably be the real reason, then they can be and should be helped pecuniarily to carry out their desires to increase the stock of fish by the County Council in whose hands their appointment lies. The revenue of a conservancy district depends most largely upon the number of rod licenses. The number of rod licenses depends upon the stock of fish. If the stock of fish is low the the revenue suffers, and the river gradually but certainly depreciates in value, until it can no longer provide adequate protection for the fish, and from what I have told you of the development of the species, this is not by any means a remote contingency.

MIGRATORY FISH—PEAL (*S. Trutta*).

Of the physiology of the Peal I will say little. There is no longer any doubt that the peal of the Cornish streams is a distinct species, the *Salmo trutta*, or sea trout as it is more generally and more correctly called. There is not the faintest noticeable difference in our peal and the sea trout of Scotland, and the migration is, allowing for the difference in temperature of the water, exactly at the same period of the year in the extreme south-west of England as it is in the north of Scotland. In fact, it is generally uniform throughout the British Isles. Two singular points regarding peal are worthy of just a passing notice. The first is the exceeding disparity in the proportion of males. My own experience, and it is also that of half-a-dozen of the best fishermen in Cornwall, is that there are at least forty female peal to one male. This fact leaves us open to consider the effect of this disparity, a matter which I believe is not clearly explained by any authority. But whatever the effect may be, whether there is an alliance with the

yellow trout, or with the male *parr* of the peal as some authorities think, is a matter yet undecided, but this we do know that the supply of peal is as great as ever it has been, and many hundreds are sent annually into the market from Cornwall during the months of June, July, and August. In the latter month great quantities of small sea trout, averaging about three quarters of a pound each run into the rivers; and this brings me to the second noticeable point which it is desirable to speak a word or two on. These fish called locally school peal do not, generally speaking, deposit. There is just a discernible formation of ova sacs, but the ova are so indefinite, and so immature, that it is impossible there can be any deposit, or at least any vivification in the season in which they run up. They probably drop back again after a short visit. The reason for this assertion is that only the *bigger* and *earlier* running peal are, by accident or design, ever caught on their downward journey. Nobody finds a "school" peal going back. It has not lost strength by depositing, and is better able to evade dangerous places, where it would be killed. I sent one of these fish to a friend of mine in London, who had just returned from Sutherlandshire, in order that he might compare it with the finnock which he had been taking at the same season of the year as we take 'school' peal, and he immediately pronounced it to be the same in every particular, flavour and appearance, as the finnock. "School" peal are the first season peal, and most delicious fish they are. They, without doubt, are the stock from which issues the bigger and more valuable sea trout of the following year. Therefore it is exceedingly important that the "school" peal should be strenuously preserved, and that the mesh of nets should not be too small. They run in August and September, and get back again, as far as can be supposed, during the early winter floods. When the stock of "school" peal is large, the run of peal in the succeeding year, all other things being favourable, will be large too.

MIGRATORY FISH—LOCAL NAMES.

Besides these two principal fish, the Salmon and sea trout, there are what may be called the questionable species, the bull-trout and truff. I never have seen a bull-trout taken in Cornwall, that is the bull-trout so recognised by authorities, and I don't believe anyone else has. Many fishermen have shewn me what they designate *truff*, and have actually in the peal-fishing season counted up their catch as, for instance "one peal and two truff." Cornish fishermen are as observant as the most cosmopolitan of men, but they do not apparently acknowledge that there is such a change in a fish as river markings. A yellow trout will alter its colour according to the colour of the water or the bed, in a few minutes ; a sea trout will do the same. A moorland trout, in black soil, will be black ; a trout in claywater will be creamy-white, and similarly a sea-trout delayed in its upward journey by drought, will assume the dark colour of the surroundings easily, and is called something else but a peal. If it is possible to designate a true truff, I should say, if it were anything, it is a yellow trout which has migrated into salt water. In support of this assertion, I may mention that I saw one of two pounds, or nearly, caught by a gentleman who was fishing with me in a Devonshire river, which had the parasitic sea lice on it, and yet had the exact markings of a yellow trout, even to the golden abdominal colour. With regard to bull-trout, Capt. Roe late of the "Black Prince," a most experienced fisherman, sent me a list of the number of the migratory fish he had taken in the Tavy, for 15 years before 1890, and he considers that at least 90 per cent. of the *Salmonidæ*, excepting sea-trout, which he caught, were bull-trout. His opinions, although they deserve every respect, are antagonistic to almost all other Tavy fishermen, and although I am not so familiar with the Tavy or Tamar salmon as I am with the Cornish, yet I have had the opportunity of seeing many salmon caught there, and I never yet saw a bull-trout among them. The

chief distinguishing marks are in the head and tail, but there are of course others no less pronounced in the gill covers, the spots, and the fin rays. Mr. Cholmondeley Pennell says: "Bull-trout are found in Cornwall and Devonshire," but although I do not presume to say he is wrong, yet I venture to offer a humble opinion, an opinion which is shared by most of our salmon fishers, that they are not. I have sketches of the distinguishing marks of the bull-trout and salmon with me, which I shall be very glad to shew any one who may be interested.

Food Supplies.

But these descriptions of species, too lengthy you will say, have taken me beyond my original intentions, and with your permission, I should like to say a word or two about the *Salmonidæ* as food supplies. The present Inspector of Fisheries, one of the most practical and able officials who has held the position, said in his farewell remarks to the Usk Conservators, of which body he was a member, that sport must be subordinated to the supply of food, and he said what all of us acknowledge to be true. For the migratory fish, the best of fish food which swims, is legislated for to be primarily food for the people. But to what extent does he, or rather do those who take hiswords too literally, consider should be the subordination of sport? Let us premise that without sport there would be, according to existing laws, as I have shewn, inadequate protection, and then go on to say that for every peal that is caught by rod and line in this county, there are seventy or eighty caught in nets. For every salmon that is caught by the licensed rod fisherman, there are fifty caught in nets, and although it is impossible to give exact figures in proof of this statement, I do not think anyone will deny it. Is it reasonable to suppose therefore that an increase of rod fishermen would decrease the food supply. Further, of every ten salmon that are caught by rod and line, five or

six of them are caught by professional fishermen : so that approximately speaking, ninety-five per cent. at least of all the salmon and peal that are caught in the Conservancy districts of the county of Cornwall go into the market. As only about one-fifth of the revenue of the rivers in the county is received from those who market their fish, it is easily seen that in the food supply, as far as it is made an industry, there is certainly nothing to complain of, while on the other hand, those who take rod licenses actually provide the great majority of the funds for the protection of the fish which go to market. This is, perhaps, as it should be, and it is right that it should be known. There can be no imperial legislation for sportsmen. The state of affairs is tersely this. "If you like to fish in those rivers where we preserve fish as a food supply, you can do so by payment of so much money, which payment will enable us preserve them." But if this is the case, one might naturally ask, why are not the nets the property of the conservators themselves? Why should not the private emolument which every net owner expects to credit himself with, be as it were, the public emolument of the publicly appointed conservators, who could use that emolument for the better protection of the fish they can ultimately send to market ? I am aware this suggestion is antagonistic to what some may call an industry ; but is it not a fact that one individual can buy a net and a license with the sole intention of reaping a percentage on his outlay ? And can we consider the ventures of a single man, it may be, when the whole community might get the benefit of this per centage, by having a self interest in the fish which come up our rivers and supply us with food ? Is it questionable logic to infer that if five-sixths of the revenue of a river come from rod licensees, who thus pay five-sixths towards the protection of the fish, that this proportion of the profits of the net owner is paid indirectly by those who pay for the protection, that is the rod licensees.

Method of Increasing Food Supply—Fish Passes.

The application of methods to increase the food supply rests with the conservators, and indirectly with the County Council. In the first place, the easiest possible means of getting into the spawning beds must be provided for all migratory fish, and this in certain seasons, entails a considerable outlay, more in fact, than can be afforded out of the limited incomes of Boards. I have sat on the rocks in December at the Black Pool weir on the Camel watching, until my heart has ached, huge salmon leaping, and leaping and lacerating themselves in their attempts to get into the highes waters, and all in vain. Some of them do get up probably, but they must wait about until they are providentially helped up by a flood; and in the meantime what is the injury done to those which are ripe for spawning, and what becomes of the salmon ? I am afraid to say, what after all, is but an opinion, although I am personally convinced it is true, that there are very many whose deposits are destroyed thereby ; and more than this, they drop back into the still deep pools where they harass and injure each other, or offer innumerable temptations to the gentry who have no employment when they have no fishing. It is comforting to know that at last the Board of Trade is arranging for better passes at this most formidable obstruction.

On the Fowey there are more salmon and peal taken in the nets than in the Camel, and although one river should be as prolific as the other, the reason lies in the fact that more migratory fish spawn in the Fowey than in the Camel, because there are no such formidable obstructions in the Fowey, and this river is consequently better stocked. If the County Council has the appointment of Conservators, the responsibility of stocking a river in a great measure depends on that body. Therefore, with all deference, I say it, the County Council would be helping to increase the food supply by increasing the stock of fish

if they were to sanction the outlay of a few pounds to be spent in minimising the difficulties in the upward progress of salmon and peal.

The treatment of spent fish, I have already spoken of. If the Camel or the Fowey flowed through a richer country, the outlay for improvements would be met by an increase in the value of the licenses. But this cannot well be done in our own county, where there are so many who would if they could, but who are unable to pay more for the enjoyable and healthy pastime they love to indulge in. I cannot help quoting here Mr. Berrington's closing remarks on the trout fisheries of England, which remarks coming from so good an authority will be echoed by all good men and true, who are interested in our own streams. "The trout fisheries of England and Wales seem to be well maintained, and the ever increasing number of anglers for fresh water fish generally affords welcome evidence that the working classes are more frequently able to enjoy their holidays in a pleasant and agreeable manner." This is as it should be. The working man who seeks his recreation by the side of the river, and takes with him his rod and line, is inculcating the gentlest and most skilful of pastimes, and at the same time is pursuing the most salubrious and pleasant of enjoyments that a change in his daily routine could suggest to him.

Gratings.

But there are two most serious hindrances to the effectual preservation of our migratory fish—two matters which it is absolutely necessary to speak of, and to offer a remedy for,—gratings at the head and tail of mill races, and pollution. These are the most formidable difficulties the authorities have to face, and at the same time they are by far the most destructive agencies existing in our rivers. But, admitting this is so, and nobody will deny it, there is no reason why the one evil should not be entirely remedied, and the other partially so. The legislature lays the res-

ponsibility of doing both on each river's executive. I have just shewn that in dry seasons like this and the last, the great majority of running fish go up mill-streams. (There is no close season for mill streams.) Everybody who knows anything about the waterways belonging to a mill, knows that it is next to impossible that salmon can make a safe passage through, even although the sweet will of the persons engaged there should be favourable to their doing so. But the law and the exigencies of the salmon themselves *demand* that there shall be a safe passage into spawning water. When there were no Salmon Fishery Acts in existence, the fish were looked after, and helped by every possible means to make a safe deposit. There was a voluntary combination of effort to increase the stock of fish. Since the Acts, the whole end of man, that is of some men, seems to be to defeat the law, and to cut open the goose which lays the golden eggs. To provide against this inevitable destruction of fish in mill streams, or to prevent what we may more delicately call an unauthorised food supply, gratings, fixed, not moveable, are supposed to be, and should be placed at the head and tail of mill-streams—the first to prevent kelts from taking this way back to sea, and the second to prevent fresh running fish from going up, as they most unfortunately do. In fact, to block up both ends. If the owner of the mill objects to this, as he might be expected to do, he will make his objection on the grounds that the grating prevents the full flow of water into and away from his mill, and I am sorry to say conservators too often take this objection to be fatal, without actually finding out for themselves by expert advice, whether it is so. It is pure nonsense to urge that the person who takes fish out of a mill-stream is liable to punishment for breaking the law. He knows all that perfectly well, but there are too many such temptations offered to riverside dwellers already. A man who sees a fish which has been injured by a mill-wheel has the commendation of almost everyone if he takes it out and eats

it, and by the natural progression of evil-doing, he gets considerable sympathy if he does not wait for it to be injured at all, but takes it out first. Perhaps he is fined the price of half-a-dozen fish, and he pays the fine. I do not blame the man who takes out a fish which he sees lying injured at the bottom of a mill-wheel. He must have superhuman control over his appetite, if he sees a tasty meal for himself and family, and, because the law directs, let it rot and decompose. I say again there is the two-fold blame on the executive for permitting temptation to be put in the man's way, and for allowing fish to run up these streams at all, and I do beg the authorities in behalf of those who have the preservation of our best of fish at heart, to make some effort to remedy this evil.

Pollution.

The matter of pollution is exceedingly difficult to legislate for. Cornwall is essentially a county which cannot do without water as a motive power, and it must adapt the natural waterways to be the means of carrying away the water coming from the minerals, which are such a source of wealth. However much we may sigh over the partial or complete destruction of our fish, we cannot, in all human reason, take any action for entirely stopping the influx of such water, and of preventing a large section of the community from earning their daily bread. Polluted water is to Cornwall what smoke is to Birmingham or Sheffield—a necessary evil. But it must not be imagined for one moment that a man, or any body of men, can by their own inclinations, and without the consent of authority pour poisonous water, or cause poisonous water to enter into any stream holding fish which are specially legislated for under the Salmon Fisheries Acts. Certainly not. Otherwise, under the plea of an industry, a single individual might re-open an old cesspit which reeks with poisonous liquids and send the dreadful compound into the fresh water, and not only kill all the fish, but kill all the

fish food, destroy all subaqueous growth, kill all the grass and foliage over which the water would flow in time of freshet, and be a serious source of injury to animals which might be led to drink of it. Therefore the person who adventures on starting an industry which would affect the water and the fish, must be prepared to confront a serious difficulty. He is actually compelled to prevent the effusion into the rivers of such mineral or other water which will be fatal to fish, whether the fatal results are prompt as in the case of a copper mine, or tardy, as in the case of a paper mill.

Rivers again may be polluted by a non-poisonous effusion of sediment which, although not fatal to mature fish, may silt up the channel, interfere with the beds, and even kill the deposit by covering it. To prevent this, and in fact to prevent the spread of pollution at all, it is ordered that all necessary precautions shall be taken—and precautions should and must be taken by constructing successive and adequate pits which the sediment shall settle in, or by making filters for separating foreign matter from the water, as far as can possibly be done. This latter expedient seems either not to have been considered, or to have been too costly to be available. It is impossible to make a filter which shall be permanently efficient in the separation of fluids. At Ivybridge, on the Erme, the outlet from the paper mills is made first to run through pits, and after that to spread itself over meadows. This is doing a great deal, probably as much as the owner who does his best for the fish can do, but even this filter must after a time be worn, and comparatively useless, as is unfortunately evident from the extremely small stock of yellow trout which are found below the outlet from the mill.

I have been in correspondence on this matter with a very clever London engineer, who has had considerable experience in Peruvian and other South American mines,

and he says, with regard to the pollution from Cornish mines, that settling tanks or pits would be decidedly useful as far as they go, but that as the Cornish miners crush very fine, the sediment would remain long in suspension. "As to chemical compounds, if in solution, you will not get rid of them except by precipitation, and that I fear would be impossible. Sewerage you are not troubled with to any extent. If you were, possibly Barnard's scheme would work in. Mr. Barnard has within the past few weeks patented a scheme for purifying water by filtering it through coal dust, and in the Mining Journal a short time ago he explains the scheme which he has invented." We may infer from this letter that if once poisonous water gets into a stream, no known appliance can prevent it killing all the fish, and the river into which it flows is from the influx of such water to the sea, ruined for all ether purposes but as a carriage for pollution. An unfortunate but inevitable result.

The rivers of the extreme south-west flow through the most picturesque and sweetly retired spots the mind can conceive. No collection of pictures is complete without a representation of some of the thousand nooks and corners of Cornish and Devon streams. The dark unrippled pool, encased in huge granite rocks, the profuse foliage, bending over it as if in homage to its value, the music of the rushing torrent through moss-covered boulders, and the sweet pastoral simplicity of the riverside cottage, or the verdant meadows, have been food for the insatiable painter and the prolific writer for many long years. But the Cornish and Devonshire streams are not written about, and eulogised, and loved because they meander through sweet scented meads and between profusely bedecked banks, they are written about, and eulogised, and loved, yes, dearly loved, because they hold fish, and fish which we hope and trust will have safer homes in the future than they have had in the past.

The Rev. St. Aubyn H. Molesworth St. Aubyn proposed a vote of thanks to the lecturer, in seconding which Mr. John R. Collins (Bodmin) said he hoped some of the remarks made by Mr. Burden would be taken to heart, and that his suggestions as to the work to be undertaken by the County Council would bear fruit. The funds of the two rivers in Cornwall (the Fowey and the Camel) were almost entirely eaten up in the maintenance of a man for each river to watch the water. If the County Council instructed the police officers to protect the food-producing salmon, and provided fish hatcheries, he thought a great step would be gained (Applause.) A great deal of the spawn was destroyed through being imperfectly fertilised, and until the fish became a year old they were entirely at the mercy of numerous enemies including eels, ducks, and rats. If there could be a fish-hatchery, in which the spawn could be fertilised, and the rearing could take place, it would, he was sure, prove very beneficial (Applause).

The motion was unanimously carried.

LECTURE 4.

(Delivered on Saturday, July 29th, 1893.)

Fishing Industry of West of England.

TRAWLING.

BY

BENJAMIN RIDGE, Esq.,

(NEWLYN, W.)

Chairman:—Colonel Tremayne.

FISHING INDUSTRY OF THE WEST OF ENGLAND.—TRAWLING.

Colonel Tremayne said his brother, Mr. John Tremayne, was announced to preside that afternoon, but unfortunately he was prevented from doing so by a severe attack of rheumatism, and he (Col. Tremayne) had to act in his stead. He was perfectly sure they would have a very vaulable lecture from Mr. Ridge, who had a practical knowledge of the subject he was going to talk about, and a lecture from a gentleman with practical knowledge was worth a great deal more than one from a mere theorist.

Mr. Ridge said the fishing industry of the West of England, though not carried on in some of its branches so extensively as at ports on the East and North East Coast of England and ports in Scotland, is nevertheless of considerable importance, and gives employment to several thousand men and boys at sea and a considerable number on shore, requiring much capital to work it, which is steadily increasing year by year, and enters into our economic experiences in that it secures to us a daily supply of most wholesome food, and calls forth from those who engage in its operations as their daily occupation many of those sterling qualities with which man is endowed, whilst it often ill repays them for their patience and perserverance and may be considered a life of toil and hardship from first to last, though not entirely without some measure of comfort and enjoyment, and induces good health which is one of the blessings of life.

Our ancestors at a very early date knew something of fishing. Swinden in his history and antiquities of Great Yarmouth, expresses his belief that the Herring fishery

began there soon after the year 1495 A.D., and Mr. Worth in his history of Plymouth, informs us that under the Romans Plymouth was doubtless occupied by that war-like people as a port for the shipment of merchandise of the western district as well as a place for fishing, and that during the Anglo Saxon period the port was frequented as a fishing station.

An old chronicler who wrote in 1485, speaking of Cawsand Bay, describes it as an open Roadstead, yet sometime affording succour to the worst sort of sea farers, as not subject to comptrolement of Plymouth port. The shores peopled with some dwelling houses and many cellars dearly rented for short usages in saving pilchards, at which time there flocked a great concourse of sayners and others dependant upon their labours.

Near the Grotto, in Whitsand Bay, were once the remains of quays and other buildings appropriated to a pilchard fishery. Later still, a fishery was established at port Wrinkle, and at Cawsand there are still the remains of cellars where the curing of pilchards was very extensively carried on as far back as the 16th century. The late Jonathan Couch published extracts from the ledger of Richard Trevill, an eminent merchant in the reign of Queen Elizabeth, and who erected fish cellers at Kingsand and Cawsand, and exported fumados, commonly called fair maids, to Bordeaux, Rochelle, to Spain and Naples, between the years 1597 and 1600. Evidence sufficiently clear showing our early connection with the fishery in the West of England, and the importance our forefathers attached to this valuable branch of our local industry. It seems pretty clear that the method principally known and used in very early times for catching fish was by the seine net and a sort of draw net. Since then, however, various methods have been and still are used in the capture of neptune's hosts, and almost every known practical means used in England are employed by our own west country fishermen, except perhaps the stow net for sprat catching, which is chiefly used by the fisherman

off the Sussex and Essex coasts. The principal methods are by the trawl, seine, drift net, hook and line, both by hand lines and long lines or boulters, moored nets and traps, set nets, trammels, lobster and crab pots, and for cray fish.

In point of history, no doubt the seine net is the most important, and even to-day is not unimportant, though it is only used for securing mackerel, pilchards, and sprats, and is not so continuously worked throughout the year as other kinds of nets, more particularly the trawl net. I purpose dealing with trawling principally in this paper, so I will reserve my remarks on the seane for my next paper. Drift fishing, as the name implies, is that practised by those of our fishermen who fish for mackerel, herrings, and pilchards with drift nets. The net being cast over board at sunset and attached to the boat, is allowed to drift whither tide and wind may so carry boat and net. This kind of fishing is of considerable importance, and there are about 40,000 men and boys engaged thereon throughout Great Britain. The most favourable type boat for this fishery among our west country fishermen is the lugger, of which you may have noticed some very excellent models in this present exhibition, and of which I shall have more to say in my next lecture, as also on the other matters which respectively have their places and bearing on our Western Fisheries.

Before passing on to the matter of trawling, I should like to say that having regard to our Fisheries as a source of food supply, its importance has not been adequately estimated, and as a point of comparison I may pnt it something in this way, vix:—One ton of fish has been said to be equal to 28 sheep, and thus the quantity of fish carried to inland towns from the various ports of Cornwall during the year 1891 were 9297 tons, and this multiplied by 28 will give for Cornwall alone during that year 260,316 sheep. You will readly admit, therefore, that any and every means to foster its development should receive encouragement whether from

the legislature or by private or public enterprise. It should also be borne in mind that the supply is brought to us daily without the trouble of cultivation, and every means should be employed to assist its growth and improve its increase.

This at once opens up a very interesting question as to transit and delivery to the teeming masses in our great towns, and also suggests that very important question of suitable harbours around our coasts for the protection of fishing craft which is so urgently needed, especially where there are so many fishing villages as there are in Cornwall. I may very fittingly refer to the efforts that St. Ives and Newlyn are putting forth to meet the pressing wants of the industry which for so many years past it has suffered from, and to say that already what these two ports have done in this matter has abundantly proved beneficial to the fishermen and every person interested in the fishing business. It is also well known to most of you present, how seriously Mevagissey has suffered in this matter with the sad misfortune which fell upon the fishermen of that port through the collapse of the harbour improvements not long since at that place.

The early history of trawling is somewhat obscure. Historians and Chroniclers have given abundant reliable information concerning the drift net fishing, as it relates to the herring, pilchard, and mackerel, and the seane net for mackerel and herring, and for what is curiously termed trawling for herrings in the Lochs of Scotland, but what is properly an adaptation of the seane net, and there is much to be found written by one and another concerning the use of hook and line fishing. But there does not appear to be any clear or reliable account as regards trawling, which differs very widely from any of the other modes of fishing, both as to the net used, the fish caught, and the manner of capture. Trawling is generally considered to have been first practised on the coast of Devonshire, by Devonshire men, about 160 years ago. Froude, however, in his history of

England, vol. xii, page 397, cabinet edition 1870, speaks incidentally of trawlers at Brixham so long ago as the time of the Spanish Armada, in the description of the English attack on the Spanish fleet, and says: "Drake returning from the chase came up with her, the Capitana, the Spanish Admiral's disabled ship, in the morning. She struck her flag and he took her with him to Torbay where he left her in the care of Brixham fishermen. The prize proved of unexpected value, many casks of Reals were found in her, and infinitely more important some tons of gunpowder, with which the Roebuck, the swiftest trawler in the harbour, was laden, and flew in pursuit of the fleet."

Trawling vessels at first were only about 20 to 25 tons burden (builders measurement) and the net was also very small, and for many years very little increase in the size of boat and net, and the number also of those craft took place, probably owing to the fact that fishing by that method was prosecuted not very far from land, principally in the bays and inshores of the coast, and as the consumption of fish in those days was not so proportionately great as at present, and the supply more than equal to the demand, very little enterprise was called for, and no alteration took place in the general method or the size of boat and net, and matters went on in a very orthodox fashion, and but little change or improvement was thought of or even required. But when inovations were suggested and circumstances needed and demanded more enterprise, the old order of things soon gave place to many improvements in both the vessels and appliances, and a substantial increase in trawling generally followed. From the few small craft of 20 to 25 tons burden belonging to Brixham and Plymouth in early times, the number has increased to something over 200 at Brixham, a considerable number of these being from 40 to 50 tons, though there is a large fleet of smaller vessels, and which during the past 10 years have increased considerably. Plymouth possesses about 60, chiefly from 40 to 50 tons. In the matter of raising the trawl net from the bottom of the

sea to the vessel's side, the obsolete hand spike winch was first used for the purpose. By and bye, as the craft and net was increased in size, the cog wheel capstan was brought into use, which since had almost wholly been replaced, especially on board the larger trawling vessel of to-day by the steam capstan, which is an absolute necessity to the equipment of a first class trawler. The trawl net is of peculiar construction, consisting of four distinct parts, singularly named back, bateings, belly, and wings, and the lower part again is known as the cod-end or bag. The back or square is a square piece of net of from 250 to 200 meshes broad, four inches from knot to knot, 40 to 50 feet long, according to size of craft, for which it is to be worked. The part of the net called bateing is made to connect to the lower end of the back or square, and by decreasing gradually the size and number of meshes till it is brought down to about 50 meshes across completes this part of the trawl. The part of the net called belly is made similarly to the bateings, only that it is used on the under part of the net, whereas the bateings is the corresponding top part. The wings part is altogether different in construction to the back and belly and partly forms the bosom of the net and is a very essential part to the whole. The head of the wings forms the bosom, and is commenced close to the head of the belly beginning with 180 meshes across, and after a few rounds of meshes are thus made is devided into three equal parts of 60 meshes each; by dropping one mesh at the inside part of every third round, and forming what is significantly termed a flying mesh, which in turn is curiously fastened to a line called the balch line, this again being fastened to what is termed the ground rope, this part of the net sweeps along the bottom of the sea ground and rakes the fish into the net leading to the cod end or bag. The various parts of the trawl are laced together and fixed to the beam by the head line and ends of the foot rope to the irons, the cod ends of the trawl are fastened strongly together by a piece of stout rope, which prevents the fish escaping the net. A peculiarity

of the trawl is the pockets, which are simply made by lacing some portion of the lower ends of the bateings and belly together, and is very necessary to a complete trawl net. The trawl heads are secured to the trawl beam, and to these heads also the bridles or spans are attached by shackles. The trawl warp is again shackled to the spans, and in this way the apparatus for trawling is arranged. The beam is of oak, beach, or broad leaf elm, 30 to 50 feet long, as per vessel, 21 inches circumference. The heads or irons are 2 to 5 cwt. according to craft. Then you have your trawl net complete.

The principal fishing grounds used by trawlers reach from Portland to The Start, and seaward from 5 to 30 miles, sometimes even within sight of the Caskets on the French shore. This ground is chiefly worked by vessels belonging to Brixham, and also work at times the grounds from The Start to the Wolf, in company with the Plymouth vessels. During the past few years, many of the larger Brixham craft have been fishing the Bristol Channel, making Milford Haven their rendezvous, which has recently sprung up as a fishing port. Plymouth as well as Brixham has been for upwards of 160 years the chief fishing port for trawlers, and continues to be used as such. Devonshire fishermen were the pioneers of the trawl fishery in the north sea, eventually establishing themselves at Hull and Grimsby, which are the largest fishing ports of England, especially in the trawling department.

The principal fish caught by the trawl are those which lay close to the bottom of the sea, viz: soles, turbot, brill, plaice, lemon soles, megrams, gurnards, ray, skate, conger, whiting, hake, tub, red mullet. In former years the hake were considered of considerable value, being so plentiful on the Devonshire and Cornish coasts, and generally found not very far off the shore; they have always been esteemed as a very wholesome food, finding nearly always a ready sale at very reasonable prices. For many years past,

however, they have not been caught around our western shore in such large quantities as formerly, and our trawlers have had to go the Irish sea, where they have been found in satisfactory numbers, and from time to time this has been a fairly profitable fishing. Prime sorts, such as soles, turbot, brill, dore, lemon soles, are those which are chiefly sought for by the trawler, because of their value.

The question of supply of edible flat fishes has of late caused considerable controversy in fishing circles, and is likely to engage the attention of every one interested in the fishing industry. A select committee of the House of Commons to consider the question of sea fisheries, and the taking of immature fish, is being held at present, which will have an important bearing, especially as regards the trawling industry of the west of England. This has chiefly resulted from the way the North Sea—the great centre of trawling operations of Great Britain—has suffered in the decrease of the soles and the quantity of small plaice landed at Hull and Grimsby the past few years from that sea.

In reference to the matter of immature flat fishes, I should like to say that whatever evidence may be given on this important matter, I regard the attention given to it by the naturalists of the Marine Biological Association at Plymouth, and the investigations carried on by Mr. Cunningham of the above association, with the results he has worked out especially in reference to the lemon sole, of the utmost importance, and further wish to say that from the practical standpoint as well as from a scientific position, it is the most valuable evidence that can possibly be given on this burning question of immature flat fishes. Mr. J. T. Cunningham referring to this question in the Journal of the Association, says: " It is certain, therefore, from the evidence reviewed, that neither immature nor undersized lemon soles are captured by the deep sea trawls in excessive proportion on any particular grounds, and the question in regard to this particular fish is narrowed down to this:—Is it necessary or advisable to interfere in an way with the capture and sale of

the smaller lemon soles, which the trawlers at present take on all ordinary off-shore fishing grounds?" In replying to this, Mr. Cunningham says: "My conclusion, then, is that no case has been made out for any interference with the capture, landing, or sale of lemon soles. Where it is found that a kind of fishing is practised which is diminishing or endangering the supply of a particular kind of fish without producing any great profit either to those engaged in it or to the community, then it is allowable to restrict or prohibit that kind of fishing. But the evidence at present available shows that any restriction of the fishing for lemon soles now carried on would be a hardship to the fishermen, a loss to the public, and of no certain benefit to the fishery." This is a wise conclusion, I think, and I am equally sure that the work being done at that station will be of the greatest benefit to our fisheries, and that whatever regulation may be necessary on such matters as already referred to will be the safer if based on the knowledge of fish life worked out and ascertained in the manner already done by the association.

According to the official returns for last year, 1892, including shell fish, the total value of fish landed at the various fishing places in Cornwall was £196,914, and for Devonshire £202,007, or a total for the two counties of £398,921. These figures compared with 1891 showed an increase for Cornwall of £14,624, and a decrease for Devonshire of £25,718.

It may be interesting to note here that the total value of fish, excluding shell fish, landed on the coasts of Great Britain for the year 1892 amounted to £6,472,696, being for England and Wales £4,628,705; for Scotland £1,590,994, and for Ireland £252,997. Including shell fish, the total was £6,923,036, being for England and Wales £4,983,272; Scotland £1,671,307, and for Ireland £268,457. It must at once be seen therefore, that our fisheries ought to be treated in every way considerately and with a view to assisting their growth.

One matter worthy of note in connection with our western fisheries is, as compared with many of the principal fishing ports of England, they are worked very much on the share system, every person on board, from the skipper to the boy, having a direct personal interest and benefit in the success of the working capital, and labour being more directly interested than in almost any other concern.

In the early days of trawling, it was the custom to work up to Saturday and finish the week, and then begin again on Monday, thus observing the rest on Sunday. Crews would go to sea on monday morning and fish for daily markets according to wind and weather, bringing in the result of their toil daily if possible, not staying at sea longer than two days at the most, thus ensuring a constant supply of fresh fish, and the buyers were always sure of finding markets accordingly. This way of working was possible so long as fish lay within a suitable distance from the shore, but in time it was necessary in certain times of the year to push further into the sea, and, to be able to grapple with the altered circumstances of the fishing, larger vessels were built to work at long distances at sea, and to remain and fish in rougher weather, which could not be done in the smaller craft. The introduction of ice in preserving fish, so as to remain at sea for several days in order to make the most of time and to be able to stay longer and fish any given spot of ground, very much influenced the trawling fishery, so that it became a very common practise for the larger craft to fish not only the home grounds, but suitable fishing grounds in the Irish sea, the North Coast of Cornwall, and the fishing grounds off the Wolf, and remain fishing for days, returning to Plymouth or Brixham with large catches, bringing the fish home in thoroughly good condition. This is the practice now of almost all the large trawling vessels of Plymouth and Brixham the greater part of the year.

As regards Brixham particularly, this development of the trawling industry favoured the chances of the smaller craft working the home grounds, and within recent years a

very large addition to that sort of vessels, ranging from 15 to 20 tons register, has taken place, and these are generally considered to be a fairly profitable investment.

For vessels not over 40 tons register, the cutter rig is certainly the most suitable, as it ensures the greatest speed with reasonable wear and tear of gear and sails, whilst beyond 40 tons measurement no doubt dandy rig is certainly the handiest and most profitable.

As regards the sale of each vessel's fish, it was certainly the custom from the earliest time to within the last 30 years for the skipper's wife to take charge of the catch on arrival and dispose of it to the best possible advantage, which again shows how directly interested were the crews and families with the general success of the going concern. In fact it was at first really a family matter, hence the presence of the ladies in the matter. The sale was effected by what is called Dutch auction, that is asking a price for a given lot, and lowering the amount at say a shilling a time until someone would say hit, which really meant that he would have the catch at the price named. This is now altered, and sale by public auction takes place by fish salesmen, who guarantee the payment for same, less commission, which is a very satisfactory method.

It will thus be seen, from what I have already said, as to the catching and selling of food fishes in large or small quantities, the development of our fisheries, the improvement of our harbours, the increase of vessels, and bringing to bear every appliance suitable to the general working of the whole—whilst of vast importance—that without adequate means for quick distribution of fresh fish to our inland towns, this growing industry would be handicapped and very seriously impaired.

The consumption of fish was purely local in days gone by, and the only means of getting neptune's hosts to the large towns was very much restricted, and was only possible by common carriers and the ordinary coach before railway traffic

was introduced. Since the opening up of railway facilities, however, in common with every other business, untold advantages have been secured to the fishing industry, and it must be admitted that no part of our trade and commerce has been more benefitted than has been our fisheries by the various railways. Markets for the disposal of fish have been thus found which must have otherwise remained unknown and unattainable, had it not been for the above facilities. It is, however, to be regretted that in the matter of railway rates for carriage of fish, unreasonably high tariffs have been imposed on our fishing industry in this matter, and the West of England has been in the worst position of the majority of fishing ports. So much of late has been said on this question that I am rather afraid detailed reference on it would be like flogging a dead horse. Nearly ten thousand tons of fish were carried from Cornwall alone to our inland towns during 1891, and over eleven thousand tons in 1892. From Plymouth, there were during 1891, 6324 tons carried to inland towns as against 7064 tons in 1892, and from Brixham 2479 tons in 1891, and 2819 in 1892.

The material conditions of our fishermen ought not to be lost sight of in all this, and any effort for their improvement in everything that goes to make up real life should command earnest attention and suitable effort. To some no doubt, fishermen are regarded as being a rough uncouth class of men, having to battle with the forces of nature under the most trying circumstances, by day and night alike, their calling being rough and ready, admitting no squeamish sentiment, they may appear from an outside appearance as unrefined men, but—I am saying what I know—underneath all this, there is a tender feeling, and in the hour of danger no class of men are more ready to face its consequences, and none more sympathetic toward suffering ones. I need scarcely remind you that our life-boats are manned by fishermen, and their deeds of bravery

in risking their lives to rescue the shipwrecked around our coast are among our nation's glory. May I not ask you to look upon them with a kindly eye, forgetting their harmless foibles, and assist every institution, whether ashore or afloat, whose object is the welfare of our fishermen. Were it necessary, I could refer to many deeds of supreme chivalry, and splendid heroism, and, taking everything into consideration, I have found them to possess the most sterling qualities of character and nobility of life.

Mr. R. Foster, C.A., asked whether it was not a fact that as soon as the County Council desired to obtain definite and accurate information on the fisheries, the men refused to communicate anything. He thought if the fishermen showed more candour, and told the County Council the "whole truth and nothing but the truth," it was quite possible the County Council would make fewer mistakes.

Mr. Ridge said until County Councils or select Committees gave fishermen some reasonable idea of what they intended to do by them they would be extremely cautious and reticent in giving information. But if the County Council showed their cards first, he did not think the fishermen would be found slow to play into the hands of the County Councils. The opinions of the Devon and Cornwall fishermen were pretty accurately represented in the evidence some of their number gave before a Parliamentary Committee in London. If the County Councils acted straightforwardly, and let fishermen see that their object was only to help them, then they would have little difficulty in obtaining desirable evidence on fishery matters. He considered the first thing to be done was to pay the out of pocket expenses of fishermen's representatives acting on the County Fishery Committees.

Mr. W. M. Grylls, C.C., asked whether steam trawling interfered with the spawning grounds, and occasioned the catching of large quantities of immature fish.

Mr. Ridge replied that as yet it had not been shown that steam trawling had appreciably decreased the supply of fish. He was, however, prepared to say that up to a certain point, steam trawling had been detrimental to the supply of flat fish generally, but to what extent he should not care to say. The Scottish Fishery Board, which possessed large administrative powers, had stopped steam trawling in the Moray Firth, because it was held to be detrimental to the haddock fishery. Although steam trawling was detrimental to the increase of the edible flat fishes the extent to which legislative interference was desirable, was a matter which only time could clearly establish.

In reply to a complaint from Mr. Myners that many immature fish were taken in some places, Mr. Ridge said the size of an immature fish depended upon the locality in which it was taken. Taking the word maturity to mean the ability of a fish to propagate its species, he might say that soles, lemon soles, brill, and other kinds of flat fish, reached maturity in the west of England at a size some inches less in length than they did on the east coast.

A hearty vote of thanks was accorded to Mr. Ridge for his able lecture and replies to questions, on the propositon of Mr. W. M. Grylls, seconded by Mr. J. C. Daubuz, C.C., and after briefly acknowledging the compliment, Mr. Ridge moved a vote of thanks to the chairman, which was unanimously carried.

LECTURE 5.

(Delivered on Monday, July 31st, 1893.)

ANIMAL LIFE IN OUR SEAS,

AND THE

Methods of Investigating it.

BY

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Chairman:—Jonathan Rashleigh, Esq.

ANIMAL LIFE IN OUR SEAS

AND THE

METHODS OF INVESTIGATING IT.

The extent to which our seas are inhabited by the various types of marine animals has long been a matter of great interest to British Naturalists. It was England which really set the example of a thorough investigation into the Fauna of its seas, and Cornwall has produced a number of distinguished naturalists who themselves have prosecuted this branch of research. Mr. Borlase of Penzance, Mr. Couch of Polperro, and Mr. Cocks of Falmouth, are well known by name to all who are interested in British Marine Zoology. Apart, however, from the purely scientific interest which a study of our fauna possesses, this subject has a thoroughly practical interest on account of its relation with our Sea Fisheries. The time has not yet passed when a considerable proportion of our countrymen believes in the existence of a sharp distinction between fishes which are good for food and the remainder of the inhabitants of the sea. Such a notion, however, is clearly not strict or scientific. The distinction between useful and useless animals, between superior and inferior fishes, is one which nature does not recognise. The same sea contains both classes of fishes—those which are good for food, and those smaller fish which are generally regarded by fishermen as so much rubbish, and are commonly designated "scruff." The one kind has to live under much the same conditions of life as the other; both have to maintain the same struggle for

existence, and to make the same efforts in securing prey and escaping from their enemies. From the fact that almost without exception our marketable fish are carnivorous, it is obvious that their food supply must consist, to a large extent, of the less valuable inhabitants of the sea; and a knowledge of the habits and movements of our marine Invertebrates is therefore of considerable importance. It is indeed indispensible for the study of any such question as the phenomena of the movements of our migratory fishes. It is clear that the habits and movements of the invertebrate forms of marine animal life, which constitute the food of fishes, must to a large extent determine the habits and movements of the fishes which feed upon them.

Now the variety of form exhibited by our marine Invertebrates, is very much greater than the variety of form to be found within the group of fishes themselves, or even within the entire group of vertebrated animals. The difference between a herring and a sea-gull is very striking at first sight, but it is much less considerable than the absolute dissimilarity of such animals as the jelly-fish and the lobster. The number of invertebrate animals is also very much greater than the total number of fishes in the sea.

Before we go into details, however, it is advisable that we should review the different types of animal life which are found in the sea and in our own seas in particular. In the first place we have a group of extremely small animals, animals so small that they are only clearly visible by the help of a lens or microscope. The only form likely to be familiar to the majority of us here is a little speck of animated jelly known as *Noctiluca*, which means "night-light," from its remarkable power of phosphorescence. In summer time, in certain years, it appears in countless myriads at the surface of the sea. It is in itself practically colourless, but when massed together in large numbers, these tiny animals form groups of a distinct salmon-pink colour. During the last two years, *Noctiluca* has been

scarce at Plymouth, but during the two years previously it was extremely abundant, and I have no doubt that many of you who were fishing or yachting during those two summers were struck by its extraordinary profusion. It is frequently mistaken for floating eggs of fishes, and that is one reason why I have referred to it here. The other members of this lowest group (called Protozoa) are not likely to have attracted much of your attention. Some of them build tiny shells for themselves, and can be found creeping about on red sea weeds, on corallines, and in the sand.

The next group is the group of sponges. The articles which we generally call sponges are really only the horny skeleton of the animals which form them, and are chiefly derived from Mediterranean species. Yet sponges, large and small, are abundant in the seas around our own shores. Strange though the statement may seem, owing to the lowly organisation of this group of animals, nevertheless Sponges exhibit, when alive, all the essential processes of growth, nutrition and respiration which are seen in any fish in the sea.

Then we come to one of the most interesting groups of all, the group of Jelly-fishes and Zoophytes, with many examples of which you are doubtless all familiar. Here on a diagram are representatives of some of the different kinds. One of the most familiar types of this group is the large jelly-fish which has such an objectionable power of stinging. To the same group belong other animals, which have not much resemblance to this jelly-fish at first sight, and which are frequently regarded as so many different kinds of sea-weed. These tiny flower-like animals spring from a sort of stalk, which branches like a shrub. Each individual or polyp, bears at the top a number of tapering processes; these are the tentacles, and you will notice that they are arranged in a circle round the margin of each polyp, with the mouth in the centre. Through this mouth the little Polyp swallows its food. Belonging to this same large group

are those beautiful animals—the various Sea-Anemones. These have the same characteristics, a mouth in the centre, and around the upper margin of the body a series of tentacles. The tentacles and some other parts of the body are always densely armed with sting-cells in the representatives of this group.

Going higher we have the group of Worms, which form a large proportion of the animals of our seas, and are of numerous kinds, forms, and shapes. Some are quite soft, and though they may be several feet in length, are altogether without any division of the body into rings, and without any feet, spines or bristles; whilst others, like the rag-worm, are divided into a number of rings, each of which is furnished with a pair of short unjointed bristly feet.

Then we have the group of shell-fish, including the limpets, whelks and winkles, sea-slugs, cuttle-fish, the members of the oyster and mussel tribes, and others. These are all grouped together under the name Mollusca. The body in Mollusca, as the name implies, is soft and smooth; the lower part is generally marked off from the upper by a deep groove on each side, and forms a stout muscular foot, as in the limpet or in the cockle. In the cuttle-fishes, however, the foot is strangely altered in appearance, as it is divided into a number of processes armed with suckers, and is confined to the very front of the body in the region of the head. But anyone who has seen an *Octopus* in an aquarium will remember that the *Octopus* creeps about upon these processes, just as a snail glides upon its foot, or a cockle jumps upon the sands with the same part of its body. Another feature which is characteristic of the Mollusca is the possession of a hard shell upon the back of the body. This is cap-shaped or spiral in the limpets and whelks, but jointed in the middle (so as to appear double) in the cockle and mussel tribe. The sea-slugs, and some cuttle-fish, however, have almost completely lost their shells.

We next come to the group known as Crustacea, consisting of those animals which, while they resemble one of the classes of worms in having their bodies divided into a number of stiff rings or segments, yet possess at the same time well-developed walking or swimming feet which are distinctly divided into a number of joints. The crab is one of this group, to which also the prawn and the lobster belong. This group forms a large element in the fauna of our seas; the animals forming it extend to all depths of the sea, and constitute an important source of food supply for our fishes. The hermit crab is an interesting specimen of this group, and we have it represented here (in a diagram). This crab tucks its unusually soft body inside an old whelk shell, and on the back of the latter are frequently to be found a number of strongly stinging sea anemones, which protect it from the attacks of ravenous fishes.

Then we come to the star-fishes, sea-urchins, sea-cucumbers, sand-stars, brittle-stars, and animals of that kind. These are all grouped together as Echinoderma, which simply means "prickly-skinned animals." They all have their skin strengthened and protected by innumerable stony prickles, spines or plates. These, with the other organs of the Echinoderma, are usually arranged in a characteristic radiating or star-like manner. The creatures themselves walk about by means of countless flexible tube-like feet, terminating generally in little suckers.

If we look upon the forms of animal life as the twigs of one great tree with many branches, the lower branches representing the Invertebrata, and the topmost branch the Vertebrata, we may say that we have now reached the highest branch of the marine Invertebrata of our seas. The Vertebrate branch, which rises beyond all these, represents the fishes and the higher animals, but from its base a short branchlet descends representing the sea-squirts or Ascidians. These curious creatures begin life as Vertebrates, possessing each a tail and a small backbone,

but do not fulfil their early promise. After a short free-swimming existence they settle firmly down upon a rock or weed, lose their tail and backbone, and grow up into ungainly sac-like animals, without eyes or ears, or power of independent movement.

Having reviewed the chief groups of animals which populate our seas, we can now look upon the fauna from a different point of view, and note the great diversity of form within each group. The sea-urchins, the sea-cucumbers, the star-fish and the sand stars are all different types, in spite of their resemblence to each other in general features. There are also many different varieties of each of these types. It is the same with the Crustacea or any other group. The crab is not exactly like the lobster, nor is the lobster like the prawn, yet these are representatives of one and the same group. If you take any one of these groups—any one of the branches of the tree of life—and follow its ramifications to their ultimate twigs, you find that this variety of structure indicates another principle which exists in nature. Although each *group* is not necessarily adapted to any set of conditions as a whole, yet each *individual species* is adapted to a particular set of conditions in which alone it can find the proper conditions of its existence. The common edible crab is not found in its full-grown condition on the sea-shore: it is found in deep water, below the influence of the tides. You find the shore-crab, on the contrary, almost invariably between tide-marks. Then there are a number of swimming crabs which slightly differ from the others, in having their hind-legs modified into a pair of oars, by means of which they swim through the water. They are naturally not usually found between tide-marks. Each particular species then, is adapted to a particular set of conditions; and this principle of adaptation strikes the key-note of the relations of animals to the physical conditions of life in the sea, at which we desire to arrive. It results from this principle, that if you take any

area on the sea shore, *e.g*, a sandy bay, you find there not merely one group represented, but representatives of nearly every group. You will find not only the crab, but the sand-hopper, razor-shells, cockles, lug-worms, tube-building worms and others, all living under the same conditions. Thus you find that the same set of conditions will support representatives of different groups. On the other hand, it is at least exceptional to find the same set of conditions supporting two very closely allied species, or, as we say, two species of the same genus.

We pass on now to consider what are the chief sets of conditions under which animal life is found to be supported in the sea. We can divide the marine fauna into two sections, characterised by different conditions of life. There is the bottom fauna, and there is the surface or floating fauna; animals on the bottom are obviously subjected to very different conditions from those floating at the surface. First we will consider the bottom fauna, which can be divided into the shore or tidal fauna, and the deep water fauna. This is a sound and natural division, as it emphasizes an important distinction between the physical conditions of the two zones of depth. The tidal zone and the zone of the sea bottom immediately below it are richer in variety and numbers of animals than the regions lower down. The reasons for this may be found in the greater light and oxygenation of the water, the greater variety of ground, and the luxuriance of plant-life which affords both food and shelter to a large number of animals. If you contrast the denizens of the tidal region with those of the deeper waters, you will find also a considerable average difference in size. Tidal species are usually much smaller than their deep-water allies. The *Purpura*, or dog whelk, and the *Murex*, are closely allied to *Buccinum*, the whelk found in deeper waters, but they are very much smaller. Again, in the case of the anemones, you find the smaller species on the sea-shore, whilst to find the largest ones you have to seek the aid of the trawler.

The grounds within the tidal region comprise rock, shingle, sand, and mud. The rocky ground is generally very rich in animals, for the reason that it presents a firm basis for the attachment of sea weeds which afford both food and shelter. Within the rocky region of the sea-shore, you find that almost every animal living there is possessed of strong organs for clinging, or for permanent attachment. I may at once refer in illustration to the anemones, which are fixed by their base to suitable surfaces of rock, or weed. The crabs also have strong claws; the sponges, barnacles, and ascidians are firmly fixed; whilst the foot of the limpet serves equally well as an organ for temporary fixation. This is an important point, because the tidal region being seriously and incessantly disturbed by the rise and ebb of the waters, if tidal animals were not provided with means of maintaining a firm hold, they would to a large extent be unable to survive within the zone in question. In the crevices of the rocks you find anemones, worms, and crabs, and also various animals of the mussel type attached by their silky "beards." The rock pools are the favourite haunts of many forms of animal life. It is here we find many anemones, delicate and beautiful hydroid corallines, tube-building worms, crustaceans, and ascidians.

The best methods of collecting upon the sea-shore are undoubtedly the simplest. Sharp eyes and ready fingers suffice for many things. A hand net is used for fishing for small crustacea in the pools; and turning over large stones is a fruitful means of discovery. A small crowbar is invariably useful upon a rocky shore. Passing to the shingly and sandy regions, the animals which predominate here are those which burrow, and protect themselves by digging into the sand. For investigating a sandy beach or shore, a spade and trowel are the best appliances you can use. In muddy regions you find much the same kind of habit adopted as on sandy shores, although this region is much less rich in variety of life, and for the most part much

less interesting than the others. The same methods of collection apply here, but a sieve will be found serviceable for separating the smaller animals from the mud in which they live.

Now we pass to the deep-water zone. Here we again have sandy, rubbly, and rocky regions, and you find practically the same means of protection adopted by animals living under different conditions as in the case of tidal forms. In the sand you have burrowing animals; upon the rubbly patches you have a variety of forms of freely moving animals; and upon rock are found fixed and clinging forms. The dredge is almost useless for the rocky regions, but may be used on the rubbly or rough sandy regions; it is advisable in the the case of sandy ground to use a moderately wide mesh so as to prevent accumulation of the sand. The trawl is an indispensable means of investigating the bottom fauna in regions where sand, shingle, and shell predominate. But these are matters of simple technique, with which I need not trouble you further. I had hoped to have shown you here the various implements used, but it is was found inconvenient to bring them into this room. They may however be seen displayed in another room in the Exhibition buildings.

Having briefly reviewed the nature of the physical conditions of life upon the sea-shore and in the deep sea, and having seen the kinds of animals which live under these different conditions, and the habits which there predominate, it is necessary to qualify the distinctions which have been drawn between the different regions by the statement that in nature there are all gradations between the various kinds of ground. This will, I think, be obvious without further remark.

We may now pass on to consider the second section of animal life in our seas—an extremely fascinating one—namely: the floating fauna. The creatures which compose it are not fixed, and they do not walk about. They are

animals which live in the upper regions of the water and must be able to float freely, to be capable of free suspension, or be possessed of swimming organs. As an illustration of these among Vertebrates, I have only to refer to the mackerel, the pilchard, the herring, and the sprat. Among the elements of the floating fauna, we have a large number of Invertebrates. The various jelly-fishes are the most striking inhabitants of this region, and perhaps the most familiar. The little *Noctiluca* is invariably found freely floating in the sea, whilst a large number of Crustacea are also found at the surface or in the intermediate regions of the sea. One of the most important classes among the latter is the Copepoda, which consists of little animals usually about an eighth of an inch long. These frequently move about in large shoals, and form an important percentage of the total animal life of the sea. They also form a most important element in the food supply of animals which live in this region, especially of the pilchard and the herring, which feed very largely upon them. To obtain these animals for observation, the method adopted is that of working a muslin net, towed behind a boat, and at various depths. This net catches different animals according to the width of mesh employed. It is, of course, necessary to use a fine mesh for the smaller kinds of floating animals, but if you want the larger kinds you will have the mesh as wide as possible, so as to let the smaller creatures through. This is a detail so obvious that it hardly needs to be dwelt upon. Experience shows, however, that considerable time is saved when nets and methods are adapted to the particular sizes of the creatures whose capture is desired.

We may now look somewhat more closely into the habits which the conditions of life have induced in floating animals. It should be noticed, that except in the case of strong swimmers like the migratory fishes, the members of the floating fauna are in the long run at the mercy of tidal, wind, and ocean currents, so far as their horizontal

movements are concerned. On this southern coast the strong tides which sweep up and down channel twice every day, are undoubtedly the most important agent in determining the distribution of the floating fauna.

On the other hand, the vertical movements of a considerable proportion of the floating fauna are determined by other causes. All the Crustacea, for instance, which enter into this fauna, either permanently or temporarily, are provided with eyes, or with such rudimentary eye-spots, as enable their possessors to distinguish light from darkness. Eye-spots are also present in a large number of other animals, especially in worms, mollusks and their larvae. Now, speaking broadly, and subject to exceptions in special cases, it is a curious fact that those animals which possess rudimentory eyes for the most part direct their movements towards the source of light; while those possessing well-developed eyes turn away from it. As examples of the former, I may mention the larvae of worms and mollusks, the free-swimming larval stages of barnacles (*Nauplii*), the *young* stages of prawns and crabs; all of these are allured by light. On the other hand, the higher Crustacea (*Amphipoda*, *Schizopoda*, *Decapoda*), which have more elaborate eyes, avoid the light, and during the day-time either burrow in sand, hide among weeds, or seek concealment in other ways; while at night alone do they swim about in careless freedom.

The alternation of day and night, of light and darkness, thus plays an important part in determining up and down migrations of the floating fauna; and the time of the day or night at which a tow-net is put overboard makes all the difference as to the success of the haul and the nature of the results.

The night is undoubtedly the best time for using the surface net, for when the sun sets and darkness arrives, the constituents of the surface fauna are reinforced by numbers of animals, especially of the higher Crustacea, which

durin the day have spent the time in hiding places on the bottom.

The alluring influence of light seems to be frequently counterbalanced in the summer months by the effects ot excessive heat, which tends to drive many animals down into the cooler strata of water; and at all times by surface disturbance and wave-action, which also tend to drive animals lower down beneath the superficial layers of wind-tossed water. One of the best illustrations of this latter principle is found in the habits of the jelly-fish *Aurelia*, which in calm weather floats in thousands in the surface layers of water in sheltered bays, but which descends to considerable depths in stormy weather. An attempt has recently been made,* and successfully in my opinion, to attribute the chief part of this reaction to the mechanism of the eight marginal "sense"-organs, which are found on the edge of the bell of large jelly-fishes; and there can be little doubt that the otoliths (or so-called auditory organs) of the smaller Hydroid Medusae have a closely similar function.

Another phenomenon that merits attention is the marked tendency towards the formation of shoals or schools which characterises numerous elements of the floating fauna. This tendency is exhibited not only by fishes proper but by various kinds of jelly-fish, by Copepods, and by numerous other kinds of Crustacea. It is another illustration of that subtle principle of "like to like" which underlies all animated nature, and which finds its popular expression in the old maxim "Birds of a feather flock together."

We must now look somewhat more closely into the composition of the floating fauna. We are justified, I think, in arranging the creatures which are found floating freely in the sea under two heads, which we may call (1) Constants, and (2) Variables.

*(By my friend Dr. C. H. Hurst, of Manchester. Of "Natural Science," June, 1893, p. 421).

Under the head of Constants, we should place those animals which pass their entire existence in the open sea, which live in a state of free suspension during the whole of their lives, constantly floating or wandering, never resting or attaching themselves upon the sea-floor, even for a single hour of their existence. Among the animals which find their place in this group are the migratory fishes: the mackerel and the pilchard, and other fishes such as the anchovy and the sprat. The herring, which during the greater part of its life, fulfils these conditions exactly, yet approaches the shore when mature, to deposit its spawn upon the sea bottom. In this habit, the herring, since it is in all other respects a typical pelagic fish, is an illustration of that exception which proves the generality of the rule. Among invertebrate animals, the greater number of Copepods, and some other small Crustacea called *Podon* and *Evadne*, several segmented worms, and the small transparent fish-like *Sagitta*, a certain number of jelly-fish (the Siphonophores and the Ctenophores, for example), and several of the lowest forms of animal life (*Noctiluca* and the *Radiolaria*) may be mentioned as typical examples of animals, which in our own seas, as elsewhere, are invariably found floating at the surface or in intermediate strata of the sea.

Under the head of Variables we should place all those animals which spend only a portion, whether it be great or small, of their lives under these conditions, the other portion being spent upon the sea-bottom. In shallow waters like our own, this second group of constituents of the floating fauna forms a considerable proportion of the whole. I had better give a few illustrations that may serve to render this point more clear and emphatic, for it is one of considerable importance.

The common jelly-fish, *Aurelia*, of our coasts, may seem to many to be a good example of that group of floating animals which I have just called "Constants." It

is, however, a capital instance of my second group, or the group of "Variables." Let me draw your attention to this diagram upon the wall, in which I have represented the process of development of one of these large jelly-fishes. In the Autumn or early winter of the year, if you cast your dredge on extensive scallop or old oyster banks, you are pretty certain to bring up, attached to the inside of one of these dead shells, a colony of little polyp-like animals, which form the first stage in our series of transformations. They are usually not taller than the sixth part of an inch; they have the shape of a slender vase, and are attached to the shell by a narrow disc below, while above they terminate in a four-cornered mouth, which is situated in the centre of a wreath of slender tentacles, whose number may be 4, 8, or 16, according to the particular period of development attained. If now, you again dredge on this same ground in the late Winter or early Spring, and secure another colony of these little polyps, you will find that a large number are undergoing, or have undergone, a most remarkable transformation. A groove has appeared beneath the region of the tentacles, and, encircling the body of the polyp, has sunk deeply into its substance, and in the larger specimens has been succeeded by a number of similar groves lower down. The polyp accordingly no longer retains its simple vase-like shape, but rather may be compared to a number of buttons, arranged in an upright pile, one above another. The 16 tentacles have shared in the general change. Half of them have disappeared altogether, and the remaining eight have been converted into tiny stumps, the rudiments of the marginal directive organs to which reference has been made above. Each of these eight stumps of tentacles, now lies in the centre of a pair of lappets which project from the general edge of the body. A similar arrangement of directive organs and marginal lappets, arises on the edge of each of the button-like portions into which the body of the polyp is being gradually divided. For the grooves continue

to sink inwards to such an extent that first the uppermost "button," and then the rest successively in regular order, are cut off from the body ot the polyp, and swim away as independent creatures into the higher regions of their watery abode. In this condition they are known as *Ephyrae.* By rapid and continous growth in breadth and thickness, by the filling up of the interspaces between neighbouring pairs of lappets, and by the appearance of tentacles in these regions, the Ephyra is gradually converted into the full-grown Medusa—in other words, into that condition of the jelly-fish's life-history with which the majority of my audience are doubtless most familar.

Thus the larger jelly-fishes are examples of animals which spend the early period of their development on the sea-bottom, and become members of the floating fauna only in the later stages of their development. In this they resemble a large number of the smaller jelly-fishes, those Medusæ, in fact, which arise as buds from the stems of the Hydroid Zoophytes. Their life-histories demonstrate the interdependence of the bottom and the floating faunas, and justify our placing these Medusæ among the Variable, rather than among the Constant, elements of the floating fauna.

As another illustration of the connection between the bottom and the floating faunas, I will now direct your attention to the diagram in which the life-history of the Common Shore Crab (*Carcinus*) is displayed. Without entering into so much detail, I may remind you that while the Crab in its later stages lives regularly on the sea-bottom, in its just-hatched and early stages it swims freely about in the upper layers of the sea. This is just the reverse of what happens among the jelly-fishes. It is, nevertheless, the state of things which is most characteristic of the Variable part of the floating fauna. For not only Crabs, but innumerable Worms, Molluscs, Crustacea, Echinoderms, Ascidians, and Fishes, with many Anemones, Zoophytes

and other animals, abound in the surface layers of the sea in their early stages of development, while they haunt the bottom in their later and mature condition.

Now the time of the year at which the young stages, or larvæ, of the Crab appear in the upper layers of the sea, clearly depends upon the time of the year during which the eggs of the Crab are hatching. A little experience is sufficient to shew that in different kinds of crab the eggs are hatched at different periods of the year; and that whereas one kind of orab may have a prolonged breeding season, and therefore a prolonged hatching season, another kind of crab may have a very short hatching season; also that in one kind of crab the process of transformation from the young larva to the adult form may take place with great rapidity, while in another kind the larva may enjoy a long free-swimming youth before it sinks to the bottom and undergoes its changes into the more familiar form of the final bottom-haunting stage.

What is true of crabs, is equally true of shrimps and prawns, of starfish and sea-urchins, of worms, mollusks and fishes. There is not one breeding and hatching period for all these forms; on the contrary, every individual form or species has its own peculiar period, which may or may not correspond with that of any other species. We are now ready to form a more vivid conception of the intimate relation between the bottom and the surface faunas, whose importance I am particularly anxious to impress upon you. Just as the breeding and hatching seasons, and the times of medusa-formation, of different species are distributed over the entire year—not perfectly coinciding, but following each other in a more or less regular succession—so there is a corresponding succession of young free-swimming larval forms rising to the surface at different times, and remaining at the surface for equally variable periods.

In this way arise marked periodic changes in the nature of the floating fauna. In the Spring the sea swarms with the *Ephyrae* of large jelly-fishes, and with a few kinds of

Hydroid Medusæ too; with the bristly larvæ of segmented worms; with an increasing number of larval stages of crabs, shrimps, and prawns. Very characteristic, too, of the Spring, is the appearance and profusion of certain small spherical or sausage-shaped gelatinous bodies, which appear to be the adult stages of a peculiar pelagic sea-weed known as *Tetraspora*. The Summer brings with it a great increase in the numbers of Hydroid Medusæ, while the Ephyrae of the Spring have been rapidly growing up into the large Medusæ, whose graceful swimming (and I might add, stinging) bells are only too familiar to every bather. The floating stages of numerous crabs, shrimps and prawns are now abundant, but the larvæ of worms and barnacles become scarcer and scarcer. Autumn is the period of the "decline and fall." The greater number of the Medusæ have shed their eggs and died, and most of the Crustacean larvae have passed through the early stages of their metamorphosis, and have sunk to the bottom, or made their way to the shore, to undergo their final changes. Some new forms, however, have appeared, of which the *Nauplius* larvæ of parasitic barnacles, the larvæ of brittle-stars and sea-urchins, and the larvæ of certain segmented and unsegmented worms may be singled out for mention. Autumn is also the season on our southern shores for a considerable incursion of more oceanic forms, of Siphonophore jelly-fishes, of *Sagitta*, and of the Crustacea *Podon* and *Evadne*, with numbers of *Copepoda*. These, it should be noticed, are parts of the "Constants" of the floating fauna, while the other forms which have been mentioned above, are entirely drawn from the "Variables" of the fauna. Winter is less marked as a period than are the other seasons: there is a perpetual succession of small changes, gradually leading up again to the richness in larval life of the early Spring.

The floating fauna thus goes through a series of periodic changes of great magnitude, and I invite your attention to the question whether this great amount of

variability (which, moreover, is regularly repeated from year to year) must not be one of the most essential factors in the causes which determine the annual movements of our migratory fish, the mackerel, the pilchard, and the herring.

These results, which I have described with the utmost brevity, have been largely obtained from observations made regularly throughout the year in the immediate neighbourhood of Plymouth. Their value and utility I willingly leave in your hands to decide. But I cannot refrain from most urgently pointing out that, since our migratory fish go out to a considerable distance from our shores, the question as to the causes of their migrations cannot be solved with that certainty which the growing importance of the problem requires, until we have pushed our investigations further out to sea, and have made a careful examination of the floating fauna in the very "chops" of the Channel. For this reason, a final opinion upon the matter cannot be given until, through the philanthropy and liberality of those who are interested in the work which we perform, we are enabled, by the possession of a stout sea-going steam-boat, to extend the area of our investigations to the distance indicated. I believe I have satisfactorily shewn at any rate that the key to the solution of the problem will be furnished by a still deeper and more extensive investigation of the seasonal changes which come over the face of the floating fauna off our shores.

Let me, in conclusion, briefly review the facts which I have placed before you. We have found in the first place, that there is a great diversity of life upon the sea-bottom, and that the distribution of animal life there is dependent upon the physical conditions of different regions. We have seen that a given form, or species, inhabits just that particular region most fitted to its particular structure. For example, there is a little Hydroid Polyp which lives attached to the rocky bottom of clear tidal pools: its name is *Clava*

multicornis. It is always found attached to rock. Very slightly, yet distinctly, differing from this is another kind of *Clava (Clava cornea)*, which is never found fixed upon rock, but always upon a particular kind of sea-weed *(Fucus)* growing in shallow water upon a muddy shingly bottom. In such estuaries as the Helford River, near Falmouth, or St. Germans River, near Saltash, where *Fucus* grows abundantly under these conditions, you may readily find colonies of this little polyp attached to the fronds of the waving weed. *Clava multicornis*, on the other hand, may be found carpeting stones, or the rocky floor of tidal pools below the Hoe at Plymouth. This is but one of innumerable possible instances of the association of differences of structure with changed habits and dissimilar conditions of existence—in other words, of the principle of adaptation.

We have also discussed the nature of the floating fauna. We have found it to consist of a constant and of a variable element, the former being especially characteristic of oceanic areas, the latter of shallow water regions. The floating fauna is peculiarly subject to change, partly owing to the effect of physical conditions, and partly to the nature of its constituents, many of which are larval or transient stages in the development of bottom-living animals. The changes due to physical conditions are principally vertical movements induced by variations of light and heat, and horizontal movements determined by the sweep of tides, and of wind and oceanic currents. The changes in the constitution of the floating fauna are periodic changes, due to the incessant rising of different larval and medusoid forms at various seasons, and to their subsequent sinking to the bottom, or their disappearance, after longer or shorter periods of free-swimming existence.

It results from the examination which we have made, that animal life in the sea is not a disorderly *mêlée* of grotesque and curious forms scattered everywhere in hap-hazard fashion; but that the distribution, the changes, and

the movements of every class of animal are determined by precise and definite conditions, which we have shown to be capable of full investigation by the employment of proper means.

We have seen that special importance attaches to an examination of the floating fauna, because the animals which compose it are in some cases the enemies, and in many cases the food-supply of our migratory fishes, and of the young stages of nearly all our fishes. To a thorough knowledge of the seasonal changes in the floating fauna, I cannot attribute too great a value. I believe these changes are important above all other conditions in determining the movements and the relative abundance on our coasts of the migratory fishes which frequent our shores. We may well hope that the day will soon arrive upon which we shall be equipped with the means to complete investigations of such far reaching interest and significance.

LECTURE 6.

(Delivered on Wednesday, August 2nd, 1893.)

THE

CONDITIONS

FOR SUCCESSFUL

OYSTER CULTURE.

BY

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THE CONDITIONS FOR SUCCESSFUL OYSTER CULTURE.

The Chairman said, the importance of the Fisheries Exhibition which was being held in Truro, and the Lectures being delivered in connection therewith, could not be over-estimated. The movement was one in which the whole County was interested, and was a practical effort to benefit one of their great County industries. Their fisheries had been of importance and benefit to thousands of their population in the past, and might they be even more so in the future as the result of what was taking place in Truro during these few weeks.

The Lecturer said: no apology is necessary on my part for the subject of to-night's lecture; there are, unfortunately, but few people who do not appreciate oysters, and here at Truro there are valuable beds in the immediate neighbourhood. But I feel that I owe you some explanation of the apparent presumptuousness of the title which I have selected for my lecture. So many attempts at oyster-farming in England have resulted only in failure that a discourse on the Conditions of successful Oyster-farming may at first sight appear a mere impertinence. But even in England, and to a much greater extent on the Continent, enough success has been attained to enable a careful student to understand the chief causes on which this success depends, and it is these which I propose to lay before you to-night. The details which are apparently of less importance, and which are certainly less clearly understood, require to be investigated separately in every river in which it is proposed to cultivate oysters, and need for our purposes be only briefly mentioned.

By oyster-farming I mean the breeding and rearing of oysters for the market, not merely the relaying of imported foreign oysters to fatten. This fattening industry is no doubt commercially of very great importance; but, since it is far easier than the breeding of oysters, its success depends upon some of the same conditions as those for successful oyster-farming, and it is not practised to any great extent here in the West, we may omit its consideration in favour of the more difficult, and, I may add, the more remunerative, industry of breeding and rearing the oyster.

Naturally enough, success is most likely to be attained in a river, estuary, or harbour where a local oyster-bed already exists, or has been known to have existed till a comparatively recent date; but even here it is most advisable to make careful experiments before commencing cultivation, in order to ascertain that none of the conditions under which oysters previously thrived have become in any way altered; the water may have become fresher, or fouled by impurities; the food may have become scarcer; in various ways a river that once produced oysters may have become unfitted for cultivation. There is another and a very important question to be considered: Are the conditions of the river so favourable that as many oysters can be reared there every year as are required to make the beds pay? In a very large number of cases of the depletion of oyster-beds, their failure has, no doubt, been due to neglect of the first principle of oyster-culture, viz., that *the average number annually dredged must not exceed the number annually bred and reared to a marketable size*. The question for the oyster-farmer therefore is, can he rear annually a number of oysters equal to that which he has to sell in order to pay his expenses? The actual answer can only be given after cultivating the beds for about five years; but a careful investigation of the beds beforehand will show whether this is likely to be favourable, or the reverse.

We will suppose that a man wishes to start oyster-farming, and desires to know whether the river that he has selected is suitable or not for the purpose. His first care should be to inquire into what may be classed as the physical conditions of the river, and find out how much nature is prepared to do for him.

1. Perhaps the most important physical condition is **the movement of the tide,** and the manner in which it is affected by the lie of the land. This is a point which has been greatly neglected, and yet is beyond doubt the key to the extinction of oysters in many English rivers. Where the ebb-tide is strong, and lasts a long time, a river empties itself almost entirely, and the ebbing water carries out to sea with it the young oysters, or spat, which are floating at its surface; when the tide turns, the drops of water that were in the river at flood do not by any means all return to it, but other drops of water from further along the coast take their place to a great extent, so that much of the oyster spat which has been swept out by the ebb is not brought back on the flood, but is lost at sea. A river such as this is unfavourable for breeding oysters; but the great oyster-breeding grounds of Europe—Arcachon in France, the East Scheldt in Holland, the Essex rivers of England—owe their success, in the first place, to the fact that the tide is kept up in them either by the narrowness of their outlet, or by the presence of bars and banks at the river mouths; in these cases the ebb is of long duration, as these is more water in the river than can get rapidly out; long before the river has emptied itself the tide outside has turned, and thus a great deal of the water in the river, carrying with it the precious oyster spat, never gets outside at all on an ebb-tide.

I said above that in this configuration of the land and its effect upon the tide there lay the key to the depletion of the oyster-beds in many English rivers. You have probably all heard of Mr. Darwin's phrase, "the struggle for life," by which he referred to the now well-known fact that every race

of animals was perpetually fighting against natural disadvantages, and against other animals, for life and food. Further, as you are also probably aware, one of the consequences of this struggle for life is that all animals produce a much larger number of eggs and young than ever grow up to maturity. In the case of the oyster, for example, the mother produces about a million eggs, of which very few ever grow up.

Let us imagine a river with a hundred oysters in it, producing on an average five young oysters a year which reach maturity, the remaining eggs and embryos having been eaten by other animals, or swept out to sea, or otherwise destroyed; as long as that bed is left undisturbed, it can just make head against nature and its other enemies, and will very slowly grow into a large bed. But then suppose a dredgerman discovers it, and takes six oysters a year from it—takes one more oyster yearly than is produced—then that bed is doomed to extinction. And this appears to be the melancholy history of many old oyster-beds in English rivers; they could just make head against their general natural disadvantages, and this great disadvantage of a strong ebb tide in particular, so long as they were left alone, but when they had to fight man as well as nature they were beaten.

2. **The character of the water** is the second physical condition which requires consideration. It must be pure, it must not be too fresh, it must contain a certain quantity of lime in solution, for the oyster to build into his shell. It must also, of course, contain the appropriate food of the oyster. Unfortunately we do not yet know exactly upon what conditions the abundance or the scarcity of this food depends; we know that it consists largely of minute plants, but no one has as yet seriously studied the matter.

As regards the depth of the water, oysters will live and thrive at very considerable depths, but shallow water is obviously best adapted for oyster-farming, as being so much easier to cultivate than deep water; up to a depth of five fathoms it is easily worked.

3. With regard to the **character of the ground** forming the bottom of the river, a naturally clean ground, free of weed, is of course very desirable; it should be firm, but not too "cold;" a light shingly marl, for instance, forms a capital ground. Sand, so long as it is a firm, rich sand, is also good, but shifting sand and shifting mud are most deadly. Many splendid oyster-grounds on the Essex rivers, and in France, are in the first instance composed of soft mud, and require an enormous expenditure of trouble and money in order to bring them to the requisite condition of firmness.

4. **The climate**, including under this head the seasonal temperatures and the weather, forms also a physical factor in oyster-farming of very great importance, although, perhaps, too much has been attributed to it in recent years. Hot, calm summers, and mild winters, form the ideal climate of the oyster-farmer, but are unfortunately not the rule in England. In cold tempestuous weather during the summer months the oyster-spat is unable to settle; in hard winters the stock of mature oysters is sadly diminished by frost. For example, during the winter of 1890-91, nearly 60 per cent. of the oysters in the Scheldt were killed. It may be noted in this connexion that the presence of large ebb-dry flats in the river is found to raise appreciably the summer temperature of the water, as they become very hot, and and warm the water as it rises over them on the flood-tide.

Given a river, or estuary, with all these favourable conditions, with a weak and prolonged ebb-tide, clean shallow water, a firm bottom, and a warm climate, the next thing to consider is the **stock of oysters.** This should be larger, much larger than would at first sight seem necessary. There are people who say, "Oh, you can't dredge the last oyster off the bed, and one oyster will give you spat enough to stock the whole fishery!" Both these statements are perfectly true; but the conclusion which is generally drawn from them, that it is impossible to overdredge a bed, is most untrue, and takes no account of the struggle for life. In the

first place, out of every hundred oysters in the breeding season, about forty are females, about fifty are males, and ten are not breeding at all—that is to say, only about four in every ten will give out spat, or young oysters. In the second place, on a cold, rainy, windy day, probably not one spat will be able to settle down and start life for himself. Thirdly, even on a calm, hot day, the little spat has innumerable foes to contend with. *There should be so many parent oysters on the bed as will keep the water full of spat during the whole breeding season*, for there may be only one good spatting day in the whole time, and there can be no doubt that the more parent oysters that there are on the bed the greater are the chances of success.

This brings us to the question of **Reserves**, of a stock of oysters not used for market, but left undisturbed for breeding purposes. It has been suggested that on the river Scheldt in Holland, where no one is allowed to dredge near the great dykes or sea-walls which protect the land, the oysters on these dykes serve as a breeding stock, to which a great part of the spat is due. On public, or semi-public grounds, such a reserve is doubtless of extreme value, but on private grounds an owner with some capital may be trusted to maintain a sufficient stock for breeding purposes.

The next question to settle is, **what kind of oyster to lay**, and it is a question not easy to settle authoritatively. If there are already oysters in the river, there is no doubt that it will be best to stick to them; it is their home, and they have adapted themselves to it. If they have become extinct, and there are still oysters in a neighbouring river, it would probably pay best to try these; but, so far as I know, the experiment has not been tried. Failing these, there seem to be only two striking alternatives, to lay in a stock of either the cheapest or the best oysters available. The cheapest are those of Arcachon in France: these have been bred successfully in England, but very rarely; remarkably rarely, when one considers the enormous number of French

oysters annually laid down in England to fatten. With regard to laying down the best oysters, it is impossible to say what their children will be like after being transplanted to a different river. The various kinds of oysters found in English rivers are what are termed by naturalists, varieties of the same species, just as there are varieties of sheep and cattle; but, unlike sheep, if they are transplanted to another river, their children will, at any rate sometimes, grow up into a new variety. If it were necessary to import oysters from a distance, it would probably be better to select oysters from Holland, where the climate is much the same as our own, rather than from the South of France, where the temperature is higher. In any case, they should lie on their new beds for some months before spatting time.

I propose now to speak briefly of the **development of the oyster-spat from the egg** before describing the methods adopted for catching it.

In a plan of the oyster the reproductive organ is seen to form a branching mass occupying a considerable area. In the case of a female oyster this produces eggs; in the case of a male oyster it gives rise to minute bodies called spermatozoa; these are provided with a long tail by which they propel themselves through the water. When ripe, these spermatozoa leave the parent and swim in all directions. An oyster, when open, is continually taking in water in order to breathe and feed, and some of the spermatozoa are swept in between the shells of a mother oyster by the current thus created. If one of these spermatozoa meets and combines with an egg, then, and only then, can that egg develop into a little oyster; and from this we learn, for the purposes of oyster-culture, that ***there must be so many oysters on the ground as will ensure the water being full of spermatozoa during the early part of the breeding season*** in order that all eggs may be fertilised. When this union between spermatozoon and egg has occurred, the egg, which a single little brick of living matter, a cell, as it is called by naturalists, falls apart into

two cells, then into four, and so on, the bricks out of which the little oyster will be built up gradually increasing in number. Soon there appear on its surface two little depressions, of which the one will give rise to the intestine and stomach, the other forms the temporary shell. By the next stage, which is known as white sickness or white spat, the stomach and intestines have appeared, as has also a muscle for closing the two valves of the shell; this muscle, like the shells which it closes, is only a temporary structure. At the next stage, which is considerably larger and darker in colour, and which is termed black spat, the intestine has become more complicated, and the liver has made its appearance. The black spat is now emitted from between the shells of the mother; and I have seen it stated, although I have no knowledge of the fact myself, that this happens chiefly on a rising tide. Thus turned out into the world, the little oyster floats at or near the surface of the water for some time; it may be only for a day, it may be for a week, according to circumstances. It is now exposed, a helpless and tender morsel, to numerous hungry enemies; if the weather be cold and rough, it will perish miserably; if the ebb be strong it will be swept out to sea to meet with new foes, and to find itself in deep water and strong currents, against which it cannot contend; but in hot, calm weather, if it be gently carried into a quiet corner by a weak current, it will sink to the bottom, and then, if it finds a suitable object to which to attach itself, it will settle down for life. This attachment is effected by a protrusion outwards of the mantle or membrane lining the shells, which secretes a horny cement.

The oyster-farmer cannot, unfortunately, make calm hot days to order, but he can provide, what is equally important, a clean hard surface, free from weed or slime, to which the little oyster may attach itself; and this brings us to the question of the various artificial methods adopted in various countries to catch the spat.

Cultivation in North Germany, and natural beds. In a natural bed of oysters the spat adheres to stones and to old oyster-shells. The most prolific of these beds at the present time is probably that of the Wattenmeer, or shallow sea, which lies between the west coast of Schleswig-Holstein and the North Frisian Islands. Here there is no great attempt at cultivation; the oysters are dredged as required for market, and young, unmarketable oysters thrown back, but no attempt is made to catch spat by means of special collectors. In England, similar beds have been in many cases, by the rapacity of dredgermen and dealers, so far reduced in number that, as I have explained before, they can no longer make headway; they do not even increase sufficiently in numbers to make it worth the men's while to dredge for them. In the Wattenmeer, on the other hand, I am informed that the beds are leased by the German Government to one firm, and that great care is taken to prevent more oysters from being sold off the beds than are annually raised to maturity. The spat is, however, left to attach itself to anything handy, and the bed is practically in a natural state.

The first improvement upon this natural condition of things is, of course, to supply in large quantities clean shells and stones such as the little oyster desires; this may be termed the "natural" system of cultivation, and is practised greatly in Essex rivers where the real "natives" are bred. The Essex system will be described in some detail later, and is here merely mentioned as the first step by which man improves upon nature.

Cultivation in Lake Fusaro, Italy.—Even the Romans, 1800 years ago and more, had devised a system of supplying artificial surfaces to which the spat might adhere. This has apparently been but little altered in the course of centuries, and is still practised in Lake Fusaro, a land-locked lake in Italy, communicating with the sea by a canal, and about three to six feet in depth. Here the parent oysters are

laid on little banks of stones, each little bank surrounded by closely set wooden stakes; at other points in the lake, bundles of brushwood or fascines are suspended from a cord stretched between two stakes. The spat adheres both to the stakes and to the fascines, and can be picked off as required. This ancient industry, however crude, forms a distinct step in advance, by supplying a clean artificial surface of wood for cultch.

Cultivation in France.—About 1858, when the once prolific oyster-fisheries of France were beginning to show signs of exhaustion, Napoleon III. commissioned M. Coste, then a professor at the Collège de France, to report upon the possibility of applying methods of artificial production to fish and oysters. His first experiments were made on lines suggested by the Lake Fusaro method, and were a triumphant success. He anchored bundles of brushwood or fascines, sixteen feet long, over the bottom of the Bay of St. Brieux, where a large stock of parent oysters had been previously laid down. Upon one fascine 20,000 oysters were counted. In the face of this experiment, it remained only necessary to find out how the cultivation could be most cheaply carried on as a commercial undertaking; and although, after the first, the system met with great difficulties, and M. Coste died in poverty and neglect, it is to him in the first instance that the enormous oyster-industries of France and Holland owe their existence. He also advocated the use of planks, stones, and of tiles as collectors, all of which are at present in use in France.

The methods of laying the tiles at first adopted were very simple, and the number of brood oysters killed by their removal from the tiles was considerable. An experience, however, of thirty years has produced great improvements in the methods; the tiles are now stacked to a considerable height (three feet), thus exposing a much larger area to the spat, and are coated beforehand with cement, as are also the the plank and stone collectors. When the brood oyster is to be removed from the collectors, instead of the adherent shell being damaged, it brings away a little patch of the

crumbling cement with it, but remains uninjured itself, and the destruction of the brood is in this manner reduced to an insignificant percentage.

In most of the centres of oyster-farming in France, dredging on the natural banks is permitted only on one or two days in the year, the Government maintaining them as reserves for the supply of spat. The oyster-grounds, whether on the foreshore or in deep water, are leased by the Government to companies and individuals, and are watched by police. By the end of June each man has carefully cleaned his ground, and prepared his collectors. The moment that the black spat is seen the collectors are all laid out; if set out too soon, they become coated with slime and weed, and the spat is unable to adhere to them. About October the collectors are taken inshore; the little oysters are flaked off from the cement, and laid out in hospitals. These are shallow boxes with galvanised wire top and bottom, which stand a few inches above the ground in enclosed ponds or parks on the foreshore, where they are hardly uncovered on the ebb-tide. In them the little oyster, protected from enemies, lifted out of the reach of mud and sand, and abundantly supplied with food, makes rapid growth; when of a good size and strength, it is sown out on the bottom of a similar park, and finally, in the more elaborate farms, it is relaid in a very shallow pond dug in the adjacent salt-marshes, and termed a claire. Into these claires, which are only about a foot in depth, water is but rarely admitted; their extreme shallowness allows them to be easily warmed by the sun, and produces an exuberant growth of the plant life on which the oyster feeds. It is hardly remarkable, therefore, that the oyster, in a few weeks, grows and fattens amazingly. It is also in the claires that the greenness of the oyster, so much dreaded in England, so much prized in France, is obtained; it is due to a microscopic plant on which the oyster feeds, the bluish-green colouring matter of which is taken up by some of the cells of the oyster.

The remarkable features of the French system as compared with others are, firstly, that practically the whole of the spat reared and sold every year is the produce of Government reserve beds; and, secondly, that it is during its whole life in artificial conditions.

The cultivation in Holland, although founded upon the French system, has been modified to suit the different conditions. While in France there are a number of places round the coast where oyster-culture is practised, in Holland it is almost confined to the east arm of the River Scheldt; this was, about thirty years ago, converted by a railway dam into a great land-locked lake, and the mud and fresh water coming down the river was thus retained in the western arm. The ebb-tide is strongly blocked by banks at the mouth of the river, and experiments have shown that it certainly requires more than one tide to take spat from the head of the river to the sea.

A Dutch oyster-farm of the more elaborate kind, consists of three sections: ground on the foreshore for laying tiles, deep water grounds for laying out year-old oysters, and what may be termed the home farm, where a store of marketable oysters is maintained, and where the little oysters are first stored. As in France, the oyster-grounds are leased from the Government, often for large sums.

After trying all forms of collector, the Dutch have decided in favour of tiles, of which about 11,000,000 were laid out in 1891. The tiles, which are all cemented, are simply laid on their edges on the ground, since soft mud or shifting sand are not so prevalent as on the French grounds. The tiles are gathered in about September, and are laid in pits about four feet deep on the home farm. Growth is slower than in France, and the winter more bitter; the oysters are therefore not removed from the tiles till about April, and are then laid in hospitals till about August,

either in pits or on the foreshore. They are then sown out on the deep-water banks for two or three years till required for market.

The chief points in which the Dutch system differs from that in use in France are the simpler and cheaper arrangement of collectors owing to the comparative absence of mud; the length of time during which the brood oyster is left on the collectors, owing to the slower rate of growth; the use of deep pits excavated on land instead of shallow pits on the foreshore, due to the greater cold of winter; and the sowing out of the year-old oysters on deep-water layings instead of rearing them in parks or claires. In Holland, as in France, there is reason to believe that the spat is mainly produced by a Government reserve, an accidental result of the regulation which prohibits dredging within 547 yards of the dykes or sea-walls which protect the country.

The cultivation in Essex, the part of England which produces the true native oyster, appears at first sight to be more simple than in foreign countries, but it is doubtful whether the general system is not the one best adapted to the special conditions prevalent; at the same time, in some respects its details are capable of improvement. The methods adopted are, briefly, to lay out cultch, of oyster and cockle-shells on the foreshores just before the spatting season, and to strip the brood from the cultch during the summer of the next year. All oysters (ware or marketable, half-ware of two and three-year-olds, and brood) are dredged up in the autumn, and laid in pits about two feet deep near high water-mark; here they remain till the following March or April, and are then sown out again in the rivers.

The Essex cultivators are hampered in various ways as compared with their more fortunate competitors abroad. In the first place, no reserve is maintained for spatting purposes, the marketable oysters in the river being supposed to serve. Now, what little evidence is available on

the matter, tends to show that this artificially fattened oyster, constantly moved from place to place, is not so fertile as an undisturbed oyster on a reserve; and, for another thing, in some places there are not always enough oysters to fulfil the canon laid down above, that there should be enough oysters on the ground to keep the water full of floating spat all through the breeding season, since there may be only one good spatting day in the whole time. Another great disadvantage in the Essex rivers is the shifting mud, which stifles the oysters and covers the cultch with slime, necessitating the constant use of harrows and rakes, and an enormous expenditure on shell and gravel to make a good bottom; this further renders the use of artificial collectors difficult. A third hardship with which the "native" growers have to contend is the ice-cold water which comes down the rivers in winter from the melting of snows; this is most fatal to oysters, and is a principal reason of their being taken into pits during the winter and spring. This snow water, and the constant cleaning which the ground requires in these rivers, militate against the establishment of a reserve for breeding beds.

This is not the place in which to suggest improvements in the Essex methods, but I have no doubt that, in some points, Continental methods might be adopted with advantage, or modified to suit the peculiar conditions of the rivers.

Having thus briefly discussed the various methods adopted in France, Holland, and Essex, for the collecting of the spat, we may now return to the general principles of oyster-farming.

The kind of collector which will give the best results in any river can only be determined on inspection of the river, no hard-and-fast rule can be laid down. It will depend largely upon the strength of the current, the character of the bottom, the amount of traffic in the river, and the local prices for shells, tiles, slates, and wood. Whatever kind of collector is adopted, it should be set out

as soon as possible after the appearance of black spat; and, with the exception of shell cultch, it should be cemented, in order to allow of the easy detachment of the brood. It is hardly necessary to add that the collectors should be set thickest where experiment has shown that spat falls most plentifully, owing to the presence of backwaters or other favourable conditions.

The after-treatment of the brood, again, must depend upon the character of the river. If growth is rapid, it can be detached when a few months old; if growth is slow, it must be delayed till the next year. In either case I am unable to conceive of any conditions under which the foreign system of hospitals would not prove of distinct benefit, both as diminishing loss and as promoting rapid growth; by this system enemies of all sorts are kept away from the brood, and arrangements are made to allow of the easy access of food. For the same reason, where it is practicable, the gathering of the collectors into suitable pits which are unaffected by rough weather, mud, and enemies, must reduce the percentage of deaths very considerably.

In any river some grounds will be found to give rapid growth, others to be best adapted for fattening purposes, and the judicious oyster-farmer will shift his oysters accordingly. But all grounds, whether for spatting, growing, or fattening, must be constantly worked; if they are muddy, the oysters and cultch must be constantly raked and harrowed out of the mud; if there are strong currents, and especially after bad weather, the oysters will drift into banks and ridges which the dredge will not touch, and which must be harrowed out; all drift weed must be removed as fast as it is deposited, and all the numerous enemies of the oyster killed or taken ashore. Except for a few weeks during the breeding season, when it is best to leave the cultch alone, the grounds should be worked the whole year through.

The enemies of the oyster, to which I have just referred, are a more serious matter than is generally

supposed. In some rivers one set of animals is found to be most detrimental, in others another. They may be roughly divided into two classes: those which actually attack the oyster, and those which affect him indirectly.

Among the animals which actually attack the oyster, the five fingers (*Asterias*), the star-fish (*Solaster*), and the burr (*Echinus*), all belonging to the class *Echinodermata*, have the same method of attack. They wait till the oyster opens in order to breathe; they then evert their stomachs between the valves, and digest him in his own shell. These animals should be taken ashore, where they are found to make capital manure. The whelks, the dog-whelk (*Purpura*), and the rough-whelk (*Murex*) have a different method of attack. They bore a small hole in the shell, and then lick the oyster out, probably by means of the long toothed tongue which they possess.

Crabs (*Carcinus* and *Portunus*) are particularly deadly to brood oysters, the delicate shells of which they break open with their claws. These and the whelks should be killed whenever met with on an oyster ground. Among indirect enemies, the boring-sponge or yellow-rot (*Clione*), and a small worm (*Leucodore*) attack the shell, and weaken it to such an extent, that the energy of the oyster is often absorbed in thickening the shell, instead of growing and getting fat. The *Clione* can be cured either by standing the oyster in the sun for a time, or by placing it in fresh water for three or four hours, and I think the *Leucodore* could probably also be cured by the fresh water, but have made no experiments on the point. All stones and dead shells infested with these animals should be taken on shore in order to prevent them from spreading. Quats or pock (*Styela*), blubber or squirts (*Ascidia*), crow-oysters (*Anomia*), nuns or chitters (*Balanus*), hard-ross (*Serpula*), and hassocks (*Sabella*) affect the oyster in various ways. They take up its food, some of them probably eat any floating oyster-spat which comes near them, and they take up space which ought to be left clear for the adhesion of the young spat.

They should all be scraped away and taken ashore, except the crow-oysters. These appear to be killed by being separated from the shell or stone to which they adhere, and may be thrown back to serve as cultch. Special dredges and harrows are required for this work of cleaning the ground.

Mussels also inflict serious injury on oyster-beds. They spin up the young oyster with their threads or byssus, and compete with the oyster for lodging and food. Being hardier than oysters, there is always a danger that they may supplant them. In places where they cannot be sold for food, for bait, or for manure, it is best to kill them, but they can sometimes be cultivated on muddy lands where the oyster will not grow, and utilised for food.

A point still remaining for discussion is **the breeding of oysters in enclosed ponds.** The obvious theoretical advantages of this method are: that no spat is lost by being washed out to sea; that its enemies can be reduced to a minimum; that an enclosed body of water becomes hotter, and is less disturbed by bad weather than does the open river. A fall of spat has been achieved in such ponds in England, Holland, and France; but, so far as I am aware, it has nowhere proved a great commercial success, for the obvious reason that it is extremely difficult and very costly to maintain the water in its natural condition. Here I can only briefly indicate the points which require special attention. In the first place the aëration of the water, the keeping the water charged with oxygen for the oysters to breathe, is a great difficulty, which is best met by making the ponds very large and rather shallow, so as to expose the largest possible surface of water to the air. The pumping of air into the water, and the driving it by fans, worked in both cases by steam power, have been tried, but are necessarily costly. Secondly, absolute cleanliness is even more necessary in enclosed ponds than on ordinary rivers, for the parent oysters are bound to foul the water to some

extent, and any further impurity is most dangerous. To obtain this cleanliness the pond should be drained early in the year, say about February, and should stand empty for a couple of months; the bottom should be ploughed, if possible, when dry on the surface, in order to turn up to the air and sun the decomposing matter below. Water should be admitted about April, and allowed to ebb and flow for a week or more, and the parent oysters should then be put into the pond. Thirdly, in rivers where a good deal of sediment falls the parent oysters and all the collectors should be raised a little above the bottom; the water may ebb and flow in the pond till black spat is seen, the sluices should then be at once closed and the collectors put in. In case of a heavy fall of sediment, the collectors should be occasionally raised and shaken in the water. Fourthly, a very careful watch must be kept on the density of the water; springs in the ground and rain water may make it too fresh; evaporation under wind and sun may make it too salt; and water must be added to correct these alterations. Lastly, the utmost care must be exercised in rearing the spat. As a great oyster-farmer remarked to me, oysters reared in enclosed ponds are like hot-house plants; they must be most gradually "hardened off," accustomed to the colder waters and rougher weather by degrees, otherwise the bulk of the crop will die in their very first winter.

Personally, I am of opinion that to grow oysters in enclosed ponds can be made extremely profitable; but in this, as in every form of oyster-culture, the motto should be "Festina lente," or, in homely phrase, "Go ahead easy." Experience should be gained on a small scale before extensive works are undertaken and capital irretrievably sunk. Nor must the oyster-farmer despair easily upon the failure of one or two crops in bad seasons; for, if reasonable precautions are taken in the first instance, skill and patience are bound to produce a harvest in time.

On the motion of Mr. Enys, of Falmouth, seconded by Mr. R. Foster, a hearty vote of thanks was passed to Mr. Fowler for his able lecture. A similar compliment was also paid Mr. Smith for presiding.

LECTURE 7.

(Delivered on Friday, August 4th, 1893.)

'The Culture of Salmonidæ'

BY

O. GREIG, Esq.

Chairman:—T. Robins Bolitho, Esq.

THE CULTURE OF SALMONIDÆ.

Mr. Greig was not present, and the Lecture was read by Mr. Gregg, Curator of the Truro Museum.

It being impossible in a lecture, to give more than a few outlines of the work done in a fishery, I shall suppose that I am speaking to an audience, who are interested in fish culture, but are ignorant of its details, though they have certain places in their "mind's eye," and would like to know what is absolutely necessary, before they set about making a fishery at one of these places. The best books I know on this subject are: "The history of Howietoun," Part I, by Sir J. Maitland, published at the Howietoun Fishery, Stirling. In this will be found plans, and descriptions of hatching, and rearing apparatus, and pond work—with an account of the failures, as well as the successes, extending from 1873 to 1879, and much useful information. "The Domesticated Trout," by Livingstone Stone, published in America, but sold by Messrs. Marston, London. This work was, I believe, written in 1872, but it has gone through several editions. It is also an excellent book, full of useful information, and is liberally quoted by many of our later authors, as an authority; in this are many plans of apparatus, and it gives a list of books on fish culture, from a long time back. "The Domesticated Trout," deals entirely with one species, the Salmon Fontinalis, or the American Char, and with the American climate. Mr. Stone entirely condemns earth ponds such as are generally used in England; and puts all faith in wooden ones. I need

hardly say that ponds dug out of the grounds are more suitable in this climate than wooden ones, unless the soil is of such a nature that it would not hold water. When about to establish a fishery, the first point to be considered is the water supply. In the West of England rain is, as a rule, fairly plentiful; but a Fishery *must* have water that never fails; the present season having been a "record one," any spring or stream that has run through the drought of 1893 is a reliable supply. The amount of water required depends on the number of fish to be hatched and reared in hatching house; and in pond work, on the area that can be utilised for ponds, and the age of the fish in the ponds. The water for hatching freshly spawned ova must be clear spring water, with an even temperature; that is to say it must rise out of the ground from a considerable depth. For eyed ova nearly ready to hatch either spring or brook water may be used, but spring water is best. For ponds brook water is best, but well ærated spring water will do. A supply of 120 gallons per hour may be calculated as sufficient to hatch out and rear to the age of one year, the produce of some 12,000 eyed ova, under favourable circumstances.

The best position for a fishery is on ground sloping to the North, and sheltered from the East. Anyone about to establish a fishery should do so deliberately. Mr. Stone mentions in "Domesticated Trout," that a man wrote to him asking the best kind of fish to stock a stream with, that ran dry in summer. I need hardly tell a Cornishman, that such water would not suit any of the Salmon family, as a permanent residence. If the water to be used does not already hold trout, try some in it for one season; the following winter, having prepared a means of hatching, let him buy some eyed ova, and hatch them and rear them in boxes himself, and so on, trying fresh work each year, for month by month something new to him will be learnt. The study takes a part of a day, and every day, the whole year through, and requires as much care to carry out

successfully, as bringing up children, otter hound puppies, or young pheasants; from the day the ova is spawned, until the fish are planted in their permanent home to furnish sport, they must be cared for.

I am of opinion that the actual value of any water used as a means for rearing fish, cannot be determined except by testing it with the fish; for water suitable for rearing trout to a year old, will not necessarily raise the same fish to the age of two years in paying quantities.

If I were to make a new Fishery, I should test the water with trout, and take the temperature daily for one year, and measure water supply to find its lowest amount, frequently testing my calculations. I should estimate its capabilities on the supposition that 140 gallons per hour would suffice for 10,000 eyed ova; if the supply when at its lowest, was not more than 500 gallons per hour, I would not attempt anything older than yearlings, except as an experiment. With a small supply of water, the ponds must be deep and narrow, say 8 feet in centre sloping up to 3 feet at end; and 12 to 15 feet wide; the length would depend very much on the site chosen, but 40 to 60 feet would be enough with a small supply of water. The rule is, the smaller the supply, the deeper and narrower the ponds, and for Salmon Fontinalis, deeper still.

I will now give an outline of the working of a fishery. One of the first things a beginner must learn, is to discard from his mind any attempt to treat the trout in his charge in a natural way; if he tries to copy nature, he will obtain poor results. There are certain natural laws that must be observed, such as, that he must keep his fish in water, and they must have food, and air, and light, and shade; as I proceed I will explain a few of the differences between a Fish Farm, and the "Natural way." The parent fish from whom the spawn is taken come first in order. I believe that in all well organised fisheries, trout

are never spawned under 4 years of age, and seldom over 12 years. The time of spawning can be regulated within certain limits, by the feeding; thus those fish that are heavily fed early in the season, spawn first, but they suffer more from fungus.

Fish in a pond are fed all alike and spawn much about the same time. Wild fish spawn at different times, some months elapse between the first and the last. The fish farmer nets the fish, and spawns by hand some 5 or 6 females into a dry milk plate, and then milts it with the milt of one male; he adds a small tumbler of water and thoroughly stirs with a feather, sets that lot on one side, and goes through the same process over and over again. After the ova has been milted, it stands for some 45 minutes, and is then poured into a pitcher and put under a gentle stream of water; the water continually overflows, carrying off all impurities and empty ova. Sir J. Maitland mentions having spawned 12 gallons of ova in one and a half hours. After the ova is cleansed, it is laid down on the grills, or whatever arrangement is preferred, in the boxes in hatching house, and there it remains until the eyes of embryo can be seen, for it is a curious fact that ova freshed spawned can be moved with ordinary care without fear of injury, but after 24 hours it is killed by a comparatively slight jar. The dead eggs are removed every second day, all light excluded, and the stream of water kept constantly flowing. The period between spawning and hatching, varies with species of fish, temperature of water and amount of water, and method of supplying the water.

The spawning of wild fish, in the natural way is, a pair of fish build a redd, the female sheds a few ova at intervals which is impregnated, or not, as chances occur. The tame ducks, or wild birds, the trout themselves and all the other species of fish in the water, various insects, and small animals, collect as if by magic, and eat it; some is left exposed, and killed by the light, or a flood

comes and washes the redd away, or a drought and leaves it nearly bare, or it is so placed that there is an insufficient current, or too strong a one, or a heavy rain or some other cause brings down a lot of mud and smothers most of it; that is the "natural way" of spawning.

I have already mentioned eyed ova more than once. Ova are "eyed" when the eyes are seen through the outer covering of the ova, but ova is to be bought nearly ready to hatch. The eyes are plainly seen and also a dark curved line; this line is the spine of the embryo; at this stage the term eyed ova is also used; for a beginner I recommend buying at this stage, mentioning in the order, that he would like to have them as near hatching point as it is safe to send them, and giving full information as to distance from station to water, and times of local trains, so that the sender fully understands the time his ova will be in transit. To hatch eyed ova, the same apparatus is required as to hatch freshly spawned ova; the same boxes will do for hatching and rearing the fry to the age of 6 weeks or two months. I quite agree with the Howietoun Fishery as to their pattern of hatching box being the most practical and simple. I buy nothing but eyed ova well advanced towards hatching, and find it more convenient to use perforated zinc trays laid on slate pencils instead of grills. I raise the water to 1¾ inches depth, and turn on about 1¼ gallons per minute current for boxes 9 inches wide, to 2 gallons per minute for those 12 inches wide. The zinc tray is more convenient for washing the eggs if dirty water gets on them. The newly hatched fry are called Alevins, and go by that name from the time they free themselves from the shell, until they begin to feed. Alevins are curious beings, they have the yolk sac attached to them, and feed on its contents; they require no care, but a constant current of water, and to be kept in darkness, and they must be carefully fenced in, or they will escape. They get into masses of thousands, with their heads all pointing one way, and several layers

deep. All their pectoral fins are working hard, and fanning the water past their gills, so that they cause a strong current to flow where they are massed; when they separate and are seen laying head up stream, one may expect them to feed: healthy strong Alevins come on to feed long before the yolk is all absorbed.

They are most interesting subjects for the microscope, the circulation of the blood and the growth of bone and formation of fins can be plainly seen. During the Alevin stage, immense numbers of wild fish must be destroyed, as owing to this imperfect development and the ponderous yolk sac, they are very helpless creatures. They require much care, they must be brought on to feed and require food frequently during the day; they must be kept very clean; they water supply should be increased gradually, as well as light. Judging by the amount of care they require in confinement, they must suffer severely when wild, without counting losses from being eaten. Ova suffers from fungus, sediment, and change of temperature. Fungus is kept away by painting or cleaning all wood work, and excluding all the light. Sediment suffocates the ova by choking the pores. I have not found any form of straining the water to be of any use; pure spring water is the only safe water to use; it must be run into a tank and allowed to settle before passing over the eggs; changes of temperature can only be avoided by using water from deep springs. Alevins suffer from little but light, which is easily excluded, most of the other diseases apparent in Alevins are from immature parents, or from an insufficient supply of water. The same may be said as regards fry. Monstrosities are frequently seen amongst Alevins; they seldom live, except a proportion of the crooked spined ones, and those with deformed jaws; these forms are also found amongst wild fish. After the fry have fed a month they are fit to turn into the ponds. Fry should be fed on eggs boiled very hard, full directions are given in the History of Howietoun. I am no believer

in vegetables as food for any of the Salmonidæ. The eggs may be given for the first fortnight, after that, meat in some form, grated very fine is quite sufficient. A beginner will find his Alevins have many diseases that will be very disappointing to him, but with experience they will disappear to a great extent, though with the greatest care and experience many will die, for 1 in 8 is a fair average to rear into yearlings; this is about the average to be hoped for. With wild fish, one in a thousand has been quoted as a high average, and I imagine it to be so, all things considered.

I will now say a little more about the ponds. Almost any pond will raise trout, even if the water is shallow and frequently stagnant, a few trout will live in it. In Sussex, I raised trout from fry to two-year olds, in a stagnant pond that was so shallow that my men always mowed the weeds in it every autumn; the deepest spot was only 3 feet deep. The salvation of the fish in that pond, was the bulrushes; they were very large and very thick, and covered all the water except a narrow strip of stones in the middle. At my present fishery I have seven small ponds, entirely dependent on rain for the water supply, and both last summer and this they have sunk to 18 inches in depth; last summer they contained two-year olds, and of this fry a fair number have lived through both seasons. Last summer, 1892, I had a strong leak in No. 8 pond, it was stocked with 60 head of fish from ½-lb. to 3-lbs. weight; it sunk to 18 inches deep, and got very dirty, still 8 of these fish lived. I marked them and turned them loose into the river last spring, one has been since caught in my fishings. These are enough examples to prove that trout will *live* in stagnant water, but no one should make a pond for any of the Salmon family unless a constant stream of water can be kept flowing through it, as in stagnant water such a large area is required for each individual that there is no profit in it. The more often the water is changed in a pond, the larger the stock

of trout, is a certain rule; the amount of food in the water is not nearly so important as many think, for it can be easily supplied, and hand-fed fish, if properly managed, grow fast. With a small current much shade is an advantage; this is to be got by making the ponds deep, by partially covering the water, or by a strong growth of weed, but nothing, however, succeeds like a strong flow of water; always remember that, leaving out other causes, all of the Salmon family consume a large amount of oxygen, and unless they get it they die; the oxygen is brought to them by the current, by the wind, and is thrown off by plants, therefore the more the water is oxygenised, or ærated, the more trout can be kept alive. They also consume more in warm water than in cold, therefore in long droughts and a failing water supply, the consumption is greater and the supply less.

In making ponds for a Fishery, some arrangement should be made for running off all the water, for unless they can be run absolutely dry, one or more fish are nearly sure to be left alive to ruin the fry when next planted; small yearlings will keep alive for many days in the merest trickle. Floods must be guarded against by digging a wide ditch, the intake of water to the ponds being regulated by pipes. There are various useful little inventions for keeping the fish in the ponds, and for screening the water so that no leaves, buds, sticks, eels, or other fish come down with the water to choke the pipes or eat the fry. No arrangement will guard against incursions of eels from below. Water rats are a nuisance in a fishery, boring holes in the banks, but the never kill fish, being vegetarians; if one is introducing aquatic plants they do damage, uprooting, even if they do not eat them; stiff clay stops rats as well as moles from burrowing, better than anything I know, but it must be stiff. Herons do a lot of damage to yearlings; they must be trapped.

The worst enemy fry have is the larva of the Dysticus Marginalis (the large water beetle) this year we killed

over 1800; there is no hope of getting rid of them as the beetles fly in at night and deposit their eggs. The larva is a very glutton and knows no fear; he will kill fry bigger than himself. They become fungussy sometimes as fish do, and are seen swimming near the surface in a listless manner; even if one does not see the larva, their presence will be known from seeing dead fry floating at the sides. The fry if killed by Dysticus larva has a very faded, empty appearance, as if only the skin was there, for this animal does not eat its prey, but sucks out the moisture through its powerful forceps. Other birds, insects, and reptiles destroy fry and fish, but the ponds are usually stocked to allow for these losses.

If fungus appear in a pond of fish, I have found Mr. Stone's remedy of earth, dug from under the sod, and liberally sprinkled over the pond, to stop the disease, though I don't think it cures those already affected. Salt will cure fungus, but it will kill all the weeds and animal life except the trout. It is a sure remedy for fungus on fish in aquariums, if applied in time; the way to use it is to have a strong solution of salt in a bucket, dip out the sick fish in a net, and immerse it in the solution, until it appears very exhausted, when it must be placed in a strong current of fresh water until quite lively, when it may be returned to the acquarium. Trout and the American char do very well in large aquariums, and are very lively and beautiful objects, but they must not be exposed to too much sunlight; there are now some very fine ones, over two year's old, in the Zoological Gardens, Regent's Park, that came from my ponds. All the necessary data about netting, preparing and sending trout on a journey, is to be found in the History of Howietoun. I have paid much attention to my fish, doing all the work myself, and have carried out many experiments; one that will be interesting to all fishermen is this, I wished to prove whether undersized fish, stunted during the first

year of their life, grew into fair sized ones if provided with plenty of food. As far as I know they do so. I overstocked some very small ponds that I keep for experiments with Loch Leven fry, and gave them no food but what they could catch; as is usually the case, some grew to be fine yearlings, but the majority were undersized, and many at one year old were from 2½ to 2¾ inches only in length. I kept many of these little ones on to the next season, gving them more room and food; during the second season they picked up, and grew to an average of 5 or 6 inches in length.

Another of my experiments has been, to test the breeds of trout and find out whether any breed had marked characteristics that were persistent. I had trout eggs from Hampshire, Loch Levens from Hampshire and Howietoun, and common trout from Howietoun, and there is no persistent characteristic in any one of these breeds; when kept in the same set of ponds and fed alike, they are in every way one and the same fish. Dr. Francis Day, in The "British Salmonidæ," proves that without doubt there is only one Trout in the British Isles, and that the characteristics observed are purely local and not persistent in any sense, being entirely dependant on locality and surroundings, and if these are changed the individual fish changes, and assumes the character pertaining to the inhabitants of its new home. This is a very curious fact, and one that every Fish Farmer should study; my own experiments extend over only 4 years, and Dr. Day's book treats mostly of wild fish. One argument that is sometimes advanced in support of the supposed value of a breed is, that deformed trout will produce deformed offspring; all trout, char, salmon or grayling, will produce deformed offspring of whatever breed they may be, so I consider this of no value. I am studying this question from a utilitarian's point of view; I want to find a breed that will improve our local race of trout by crossing with them, and as far as I have gone, I find the breeds I have

tried all appear to be undistinguishable in any way from the trout of the district, when raised from the egg in this district. They are the same in color outside, and when cooked; they are neither longer, nor shorter, nor thicker; there is no difference in their anatomy, the colorings are the same, and they are not gamer when hooked, neither do they grow more quickly.

There are only four species of the Salmonidæ in the British Isles, viz: the Salmon, the Trout, the Char, and the Grayling. Fish Farmers have introduced the Fontinalis from America, and it has become very common now; the Rainbow is getting popular; this latter is the only species I have found with an abnormal growth in my ponds, but I have made only one experiment with them.

Our native trout is the fish I put most faith in as an object for sport, but there is still much to learn about its migrations and habits. My opinion at the present time is, that give our British trout plenty of food all day and every day, and—no matter where he or his parents come from—you will find him to grow quickly; or, in other words, the trout is formed by his diet. It will be seen from this that I am no believer in any breed of trout being superior to any other breed for re-stocking. A change of breed is probably an advantage, therefore I get all mine from Scotland.

The way to improve a fishery for sport is to increase the food supply and to make shelters for the fish, It is quite possible that trout, as a rule, migrate to the sea, and become sea trout, after attaining a certain size, especially in such streams as we have in Cornwall and Devonshire; that they move considerable distances both before and after spawning, is certain.

This migration question is a very important one, and requires investigation. Re-stocking must be done, and as the human race increases, it will become more of a necessity. Also the pollution of our rivers must be prevented, or, at all events, be kept within reasonable limits.

The Chairman said they were much obliged to Mr. Gregg for the interesting manner in which he had read the lecture. He hoped the lecture would be the means of starting one or two fish farms in the County. Some of his friends had tried experiments in this direction. Whether they had been profitable or not he could not say, but they had certainly been amusing, and if as the result of this lecture, they could be induced to increase the stock of Salmon, he was sure it would be appreciated in more ways than one.

LECTURE 8.

(Delivered on Tuesday, August 8th, 1893.)

SOME NOTES

ON THE

FISHERIES of CAPE COLONY

BY

GREVILLE E. MATHESON Esq.

Chairman:—W. E. BAILEY, ESQ., C.C.

SOME NOTES ON THE FISHERIES OF CAPE COLONY.

The Chairman said it was desirable not only that they should be acquainted with the fishing industry, as it was practised in their midst, but that they should also be aware of the various systems in vogue in different parts of the country, and different parts of the world. In hearing that afternoon how the fishery is conducted at the Cape, he thought they would learn not only a good deal that was interesting, but a good deal that would be of value to them. He had heard it remarked during the last few weeks that Cornish Fishermen did not wish to learn, but that was contrary to his experience. He found they were as anxious to learn as anyone else, provided something could be found to be taught; and he thought this series of lectures would be conducive to the interests of the fishermen, and do great good to one of the chief industries of the County. (Applause).

Mr. Matheson said: respecting what follows, I must be regarded as only a humble mouth-piece. Knowing that many Cornishmen find their way to the Cape of Good Hope, to work at the various mines in South Africa—at the great copper mines in Namaqualand, the wonderful diamond mines of Kimberley, or at the rich and important gold fields of the Transvaal—it occurred to me that a short account of the fisheries of the Cape and its immediate vicinity would not be without interest to visitors to this Exhibition. I accordingly wrote to a friend at Capetown, who is an enthusiastic fisherman and a very well-known

pisiculturist, to enlist his sympathies; and he readily responded, sending me notes from which this paper is built up, together with some specimens, photographs, &c., which may be seen in Messrs. Donald, Currie & Co.'s exhibit in the Loan Collection.

The fishing industry is well nigh exclusively in the hands of the Malays and half-breeds. Their methods are almost as primitive as themselves, and that is saying a good deal. What only was known to their grandfathers is only known to them, and there is no doubt that the fisheries at the Cape might be built up into a great and paying industry, for the present native ideas of fishing could easily be improved upon and enlarged. To-day they go about in a careless happy-go-lucky style that is altogether out of keeping with the advanced ideas of the present age.

With regard to the fishermen themselves; those at Kalk Bay and Hoets Bay, and similar places distant from towns, usually adopt the calling when young and follow it all their lives; but in Cape Town many of the men are carpenters, masons, and dock coolies, or cabmen, who only go fishing when they cannot get other work; and, even when to go fishing pays best, they frequently prefer to remain on shore, lest they should be unable to obtain employment during stormy weather, when boats cannot go out.

The Malays are very conservative, and impatient of any invasion of what they consider to be their peculiar preserves. In 1890 an American schooner, commanded by a certain Captain Josiah Chase, appeared upon the scene with a large purse-net for catching mackerel for export to the United States. Besides mackerel, other fish were caught and sold locally by the enterprising American at cheap prices as compared with those charged by the ordinary fishermen. A panic ensued, and the American was threatened and obliged to stop selling fish locally.

The fishermen got up an agitation, and were supported by certain politicians who managed to get the Fish Protection Act of 1890 passed, an Act which prevented the use of the purse-net within the territorial limits. This Act was ill-conceived and badly worded, which has practically made it inoperative. It was a piece of hasty legislation which was to have been repealed last year, but the bill for its repeal was amongst the innocents slaughtered at the end of the Parliamentary Session.

The Malays are a pleasure-loving people, and usually contrive to spend at least three days of the seven enjoying themselves picnicing and dancing in their picturesque holiday attire. Their wants are few, they live principally on fish and rice, and are a sober and, as a rule, a law-abiding people.

Fish are plentiful all along the coasts of the colony; but the fishermen complain that they are scarcer now within a few miles of the shore than they used to be. Beyond these few miles into deeper water, the Malays do not care to follow the fish with the small boats in use, a model and photographs of which may be seen in Messrs. Donald, Currie & Co.'s exhibit. These boats were designed, and a specimen built about 50 years ago, by White of Cowes, in the Isle of Wight. They are open five-oared boats, sprit-rigged, with a crew of four or five men. As a rule the owner lets out his boats, taking as tithe or payment one out of every five fish caught, not counting the ultimate division of the profits. Some of the owners are the happy possessors of ten boats, and as such get a pretty fair return for their ownership. The usual hour for making for the fishing grounds is from one or two up to five a.m., the boats returning between twelve and two p.m. Saturday, as with their white brethren, is the Malays short day; while on Friday, which is their Sunday, about one half of them are usually at the mosque for a short period. Practically they know no Sunday as we understand the day. The most of the fish are sold to

men who undertake to purchase them at a certain figure per head for a set period, and the balance are hawked about in fish carts, heralded by the fearful and wonderful tootling of a tin bugle. There are about 300 sailing boats and about 1,400 fishermen employed in fishing at the different ports of the colony, but the demand far exceeds the supply of fish, now that the railway is opened to Johannesberg and Pretoria. "Cape fish," wrote the *Cape Times* of the 26th April last, "has now become a regular article of diet in Pretoria and Johannesberg, and it has been sold as low as 8d. per lb. It is delivered in very good condition, the distance by rail between Cape Town and Pretoria being about a thousand miles." The railway department are building refrigerator cars for conveying the fish to the up-country markets, and an enterprising fish-dealer has started refrigerators in Cape Town, Port Elizabeth, and Johannesburg, for storing the fish and ensuring its being supplied to the consumer in good condition.

A Fisheries Commission was appointed in 1892 by Government to enquire into and report on the subject of sea fishing on the coast of the Colony. One of the recommendations of this Committee was the introduction of a suitable fishing smack of about 45 to 50 tons, having the latest appliances for catching, salting, and storing fish, and a well for carrying fresh fish, this smack to be manned by trained British fishermen, under the command of a master mariner of proved experience of the coast, for the purpose of fishing on the Agulhas Bank and elsewhere beyond the present fishing limits, with a view to stimulate the enterprise of the local fishermen by proving, if possible, that such a class of vessel would pay better than the present fishing boats, which are only suitable for fishing close to the land, while, at the same time providing the means for tapping the reputedly prolific Agulhas Bank and adding to the food production of the country.

The nets in use at the Cape are the seine, measuring from ten to fifteen feet in depth, and from eighty to one hundred and twenty fathoms in length, with a mesh varying from $\frac{3}{4}$ inch to $1\frac{3}{4}$ inches, principally used for catching "harders" and mullet near the beach; the set net, measuring about seven to ten feet in depth, and from one hundred and fifty to two hundred feet in length, with a mesh varying from $3\frac{1}{2}$ to 6 inches, for catching galleon, &c., near the shore; and the beam trawl for catching soles. The beam trawl is only in use at present at Algoa Bay, where a fair quantity of soles is caught for the up-country markets and the Cape mail steamers, which take a large number into their refrigerators for consumption on the homeward voyage. It has been tried in Table Bay, where soles are also plentiful, but the crawfish are so numerous that they filled the the trawl in a few minutes' time, while only a few soles would be caught, as the trawl had to be capsized to get rid of the unwelcome crawfish. Now, however, an important manufactory has been established in Cape Town by a French firm to can the crawfish for the French market. Capital to the amount of £20,000 has already been put into the business, which cannot fail to become a profitable concern.

The present primitive mode of catching the crawfish by means of a line baited with large pieces of fish or meat in which the crawfish fasten their claws and are hauled up into the boat, will, no doubt, one of these days, give place to a steam trawler, which could catch soles and other fish at the same time. This crawfish canning industry is, as I have said, likely to turn out a great success, as the supply is considered to be practically inexhaustible; and the demand, it is said, will always keep pace with the supply, owing to the increasing scarcity of lobsters in Europe and America. The young crawfish, when about four or five inches long, are particularly good eating, almost equal to lobster, but the full grown crawfish are not so palatable. They are largely used as bait

by the fishermen, and as food by the poorer people, as they only cost about a penny each on the market. The crawfish are landed in thousands every fine morning on the beach in front of the factory. Six boats are employed; the average daily supply being from 8,000 to 10,000 crawfish. Some mornings as many as 16,000 are landed, and before five o'clock in the afternoon, after having passed through various more or less interesting and more or less painful operations, are packed away in prettily labelled tins ready for export or local consumption.

The most valuable of Cape fish is undoubtedly the "snoek," not only on account of the estimation in which it is held by the poorer section of the community as a cheap article of food, but because of its value for export to Mauritius, where it is highly prized by the coloured population. It is salted and dried in the sun, and shipped in bundles to the extent of about 4,000,000 lbs. per annum, valued at £20,000. The snoek is a very voracious fish, and when in large shoals, as it frequently is, it creates great havoc amongst the smaller fish that frequent the coast. The small fish are often driven into the dock at Cape Town in such large numbers that as much as from 50 to 100 tons, and on one occasion 128 tons, have had to be removed from the Graving Dock after pumping the water out. The snoek is caught by the hand line. The hook is usually of brass without a barb, to allow of its being detached quickly. The lead, about two inches long, is cast in the shape of a cone, through which a wire snood runs, attached to the hook. The snood is made of five or six short lengths of brass wire twisted and softened in hot ashes. It is usually about two feet long, and requires to be renewed frequently on account of the way it is torn by the sharp and formidable teeth of the snoek. Between the hook and lead some strips of shark skin are fixed; a bit of white and red tape or braid will do as well, but shark skin is preferred, being tough and capable of standing far more wear and tear. This forms an attractive lure to the snoek while the boats are sailing or

rowing leisurely. It is occasionally too fastidious to be caught by this artificial bait, and then it has to be tempted with a choice bit of mackerel, which it cannot resist.

During the season, one may often come across such a paragraph as the following, cut from a Cape paper: "Already some excellent catches of snoek have been made by the local fishermen, who now sally forth daily in a fleet of about sixty-five boats to rob the deep. On Monday about 26,000 were landed, and on Tuesday about 30,000—a splendid haul."

When caught, it is hauled in with a steady strain on the line, whipped under the left arm, and held by the eyes with the left hand, while the right performs the office of dispatching it on the head with a knobkerrie! It is cut open at the back from tail to head, well cleaned and washed, then salted in a tub where it is left for a day. It is then hung up to dry for two or three days, when it is ready for packing and export.

The stock fish, the seventy-four, the elf, the galleon, and the king klip are very good table fish, and the milk fish is also said to be excellent, but, as it is rare, it is very seldon offered for sale. The geelbeck and kabeljauw, both large fish, are always in great request; the former, although somewhat coarse, is largely used for making pickled fish. The fish is cut up in pieces measuring from 2½ to 4 inches, which are called "Moetjes." These are cleaned and laid in pickled water for a day, after which they are salted and packed in tubs, where they remain for about ten days; they are then pressed in the tub by placing weights of about 100 lbs. on top of an easy fitting lid, and left for a month, when they are fit for sale. They are largely purchased by the farming community as rations for the coloured labourers. Neither the geelbeck nor the kabeljauw is now cured or dried for the Cape's only market—the Mauritius—as they are not nearly so well liked as the snoek. As a staple fish for inland consumption, the geelbeck may be considered to be in good demand. The kabeljauw is not caught in such

numbers as the geelbeck, though it frequents both the west and east coasts, and when half grown is a good table fish.

The silver fish, next to the snoek, is the most important commercial fish at the Cape, and is in great request at all times. It is caught in False Bay, as well as on the east coast of the colony, and sometimes it visits parts of the west coast—chiefly in the winter months, when the temperature of the water is lower than usual. It is in great demand amongst the poor, as it is a cheap and wholesome food. The Hottentot fish has a decided flavour of its own, but is not caught in such abundance near the shore as it used to be. It is more particularly a west coast fish, and grows to a size equal to seven or eight pounds, and sometimes more. In search of this fish, the Cape Town boats occasionally get as far as Dassen Island to the north-west, where it is generally to be found in large numbers, but as the time occupied on the journey, a distance of forty miles, takes up a day or two, and as the winds during the summer prevail from the south, this fish is usually brought home split and salted for the market. The white stump nose is generally found in great shoals, and is to be had everywhere by means of a hand line. The red stump nose is as plentiful, but is a very coarse fish, unless half grown, when it is tolerably good. The harder, or mullet, and the mackerel, are to be found almost everywhere on the east and west coasts, the former being the better fish of the two. The harder, which tastes rather like a herring, is caught in shoals very close to the shore, sometimes as many as 5,000 and upwards, being secured in one haul of a small seine. At one time this fish was pickled and exported to the Mauritius, packed in barrels, but the venture did not prove a success. Although the Cape mackerel is plentiful enough, it is used by the fishermen chiefly as bait for larger fish. There are many other kinds of fish of good quality which are in great abundance, especially along the eastern coast, but with the exception of the skate and the

sand creeper, which are not found in large numbers, the sole is, as far as known at present, the only edible flat fish they possess.

These are the principal marketable fish caught off these coasts; but the lesser varieties, such as the Sardine and the Sprat, swarm in countless millions, and no better proof could be afforded of the enormous supply of fish frequenting the shores of the Colony than the fact that up to the present day, the requirements of all available markets in the southern portion of the Cape, and the Mauritius have been met by nets used occasionally in a small way, and by little open boats which, unless by accident, are very rarely absent from port for a night, being away at the outside for only about twelve hours; for they are able during the seasons to catch all the fish they need in four or five hours, at a distance of only a mile or two from the shore.

There are two known kinds of poisonous fish in Cape waters. The smaller of these two rejoices in the euphonious name of "Billy-blow-up," and is a vile looking little object, shaped not unlike a toad, with a small mouth. It owes its name to a habit it has got when caught, of blowing itself out as if in righteous anger. The other kind, the larger of the two poisonous varieties, is, as a matter of fact, good eating enough, being only poisonous during certain seasons of the year. It goes by the name of "Keeler." The Malay fishermen assert that during the poisonous period they can easily trace a dark dirty streak in the water with an amount of phosphorus surrounding it far beyond the usual quantity. Notwithstanding this, however, a few of the Malay fishermen themselves, who, according to their own showing, ought to have known better, have died of late years from the effects of eating this fish; so that on the whole it is a matter of congratulation that they are not over plentiful. At odd intervals, to, the mussels are dangerous eating.

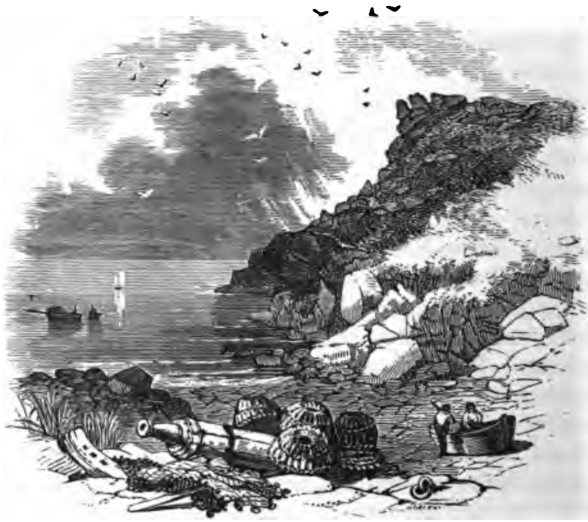
Great destruction is done to trammels, and other set nets, by small sharks, much to the indignation of the native fishermen who—holding the belief that they drive all other fish away before them—when they catch one, cut off its nose and send it adrift with a pious prayer to Allah that it may starve to death, unable any longer to sniff out its prey,

To the lover of the sport, the deep sea fishing in Cape waters has many attractions. Perhaps for choice of location, Simon's Bay and Kalk Bay afford finer sport than Table Bay. The scenery from the ocean is well worth enjoying, with the overhanging cliffs in all their rugged grandeur, and the little shore settlements fading away into space, and looking but mere white specks on the horizon. There is something also peculiarly invigorating and buoyant in the air of False Bay, it carries strength and vigour in every breath, and as the expectant sportsman journeys towards it from Cape Town and inhales its delightful fragrance, he feels tingling health in every vein, and has the appetite of a hunter. There are several fish that afford good sport with a short rod and reel, and good strong tackle. The Steenbrass, weighing sometimes over 100 lbs., and measuring some 3 feet in length, gives capital play. The "Seventy four," a very handsome fish, large in body and scales, about two feet long, with its back and sides a glorious sunset red, tinted with pale blue, with again a tinge of orange near its tail, is a plucky fish. The Geelbeck, Galleon, Kabeljauw, and Snoek, also afford good play. The bait most in vogue is crawfish and "Rooi Bas" (red bait) a species of Zoophyte, enclosed in a rough kind of case, picked off the rocks at low tide. It is a well-known fact, I believe, that anglers are just the one class of people who are not given to exaggeration, otherwise one might be tempted to take such a statement as the following, taken from the *Cape Times*, *cum grano*: "A few mornings ago a small party of gentlemen at East London, went into the roadstead, and

after about five hours' fishing, raised close upon 600 fish, only nineteen lines being used in the operation. That is at the rate of two fish a minute." Much more might be said of Cape Sea fishing. Not half the story is told, but I may just refer to the attempts now being made by the Government of the Cape Colony to acclimatise trout here.

In 1884, Mr. Maclean, of the Castle Mail Packets Company, Limited, took out to the colony 20,000 trout ova, and commenced systematic fish culture. In spite of several unavoidable catastrophes, for it must be borne in mind that this was a new experiment in a strange country and under great climatic changes, there are now upwards of 1,500 yearling trout in the store pond at Newlands, a suburb of Cape Town, averaging 7 inches in length; and at the present moment there are more than 40,000 fry in the trays of the hatchery, the produce of two boxes of ova, sent out by Mr. Andrews, of Guildford, and one box sent from the Howietoun Fishery, Scotland, in February last. These were brought out, as on previous occasions, free of freight, in the cool chambers of the Castle Line steamers. The majority of these are to be placed in suitable rivers in the colony. The yearling fish, now enjoying their daily rations of four pounds of beef, are to be kept for breeding purposes; for this is considered essential to the successful carrying out of the experiment, a consummation devoutly to be desired.

Mr. Matheson was heartily thanked for his lecture, which he illustrated with a very interesting series of lime-light views.



LECTURE 9.

(Delivered on Wednesday, August 9th, 1893.)

THE MIGRATIONS & HABITS

OF THE

PILCHARD,

BY

MATTHIAS DUNN, Esq.

Chairman:—W. H. Williams, Esq.

THE MIGRATIONS AND HABITS OF THE PILCHARD.

MIGRATION.

In reading through the works of our greatest icthyologists, one cannot but be struck with the fact, that there is no information given respecting the migrations of the pilchards which frequent the neighbourhood of the British Isles. In the year 1872, Mr. Howard Fox, in his vaulable work on "The History and Statistics of the Pilchard Fishery," remarked (p. 28). "The habits of the pilchard, and the causes that the determine its appearance on our coasts are still unknown" During the past thirty years I have been collecting information on this and kindred subjects, which I now venture to lay before you.

The pilchard, *Clupea pilchardus*, is widely distributed in the ocean, and may be found in almost every sea throughout the temperate and torrid zones. I shall, however, confine my remarks chiefly to the pilchards of the waters of Great Britain and Ireland.

The winter home of the pilchards frequenting the coasts of Devon and Cornwall is the English Channel. Of this, I think I can give abundant proof: the trawl fishermen of Plymouth, Brixham, and Weymouth, and the mackerel fishermen of Newhaven, Plymouth, Mevagissey, and Mount's Bay, often see, deep into the English Channel in the winter months, pilchards gathered up into "schools" by day, with whales, porpoises, gannets, and gulls holding wild carnival around them. While the later fishermen,

when sailing from the mackerel grounds by night, about Christmas time, when the water is in its phosphorescent or "briming" state, and when off Torbay, the Start, and the Eddystone, often pass through some square miles of pilchards. Moreover the Weymouth, Brixham, and Plymouth trawlers, when fishing off their own ports in the winter months, find the stomachs of the hakes caught in their trawls glutted with pilchards.

Again, late in October, 1878, when my brother, Moses Dunn, was fishing for mackerel to the west of Dungeness, the sea gave indications of quantites of pilchards in that locality, and in the night some hundreds got entangled in his mackerel nets. So Mount's Bay boats, when returning from the late North Sea herring fishery, and about half-way down the English Channel, have passed through vast quantities of pilchards briming by night. Several of our own fishermen, who have been to sea in the winter, notably those on board the schooners *John Pearce* and *Sophia,* of Mevagissey, have more than once described to me the masses of pilchards they had seen in the English Channel beyond Portland.

And beside all this, since pickled Pilchards have been wanted in the Italian markets, we have a large pilchard drift net fishery in the waters between the Start and the Eddystone, carried on in the months of November, December, and January, when thousands of hhds. of pilchards are yearly caught.* These facts, I think, fully prove where our pilchards exist in the autumn and winter months. That pilchards do not willingly go beyond the Straits of Dover and into the North Sea in winter, is known to most observers of fish life in the English Channel. The shallowness of the sea there affords them

* Between 1860 and 1870, in pursuing the herring fishery in December and January, in Bigbury Bay, to the east of Plymouth, it was nothing uncommon for me to see every year vast masses of pilchards. They were the dread of all the fishermen, who feared they would get into the nets instead of the herrings, as at that time of the year there was seldom a market for pilchards under the old dry method of curing.

no instant retreat into deep warm water, a necessity of their continued existence in these northern latitudes, where violent changes of temperature are found. More than once, in excessively cold winters, the English Channel has not been deep enough to give them the necessary protection, and at such times I have known countless millions of them to die. Like the conger, cold weather causes them to lose all control over their air bladder, and they will rise, belly upwards, to the surface of the sea, where they soon expire.*

Couch writes of pilchards being plentiful off Yarmouth in the years 1780, 1790, 1799: I think there can be no doubt these fishes were driven into the North Sea by whales and porpoises. There cannot, I think, be less than six to ten thousand of these creatures continually in the English Channel, and when these beset masses of pilchards they can drive them almost anywhere. Only last week (July 2nd) we had several fine "schools" of mackerel in our bay, and our fishermen were doing well in catching them, when full a thousand porpoises ranged through the bay, driving everything in the shape of fish before them. One man saw the porpoises throwing fish out their mouths in play, just like a cat with a mouse.†

Mr. O. T. Olsen, F.L.S., in his recently published Piscatorial Atlas, indicates that pilchards are sometimes plentiful in the Moray and Firth of Forth; but he has evidently mistaken the shad for the pilchard, for he states that pilchards are from two to four pounds in weight.‡

In the winter months pilchards may be found in almost any locality in the English Channel, the deep-water

* In the winter of 1870, our mackerel boats were sailing through dead pilchards for days together, so cold was the weather just before it in the channel, that the sailors were frost bitten and died on shipboard, and the vessel drifted on shore near the Deadman.—M.D.

† I have seen a single porpoise drive tens of thousands of pilchards at will as easily as a dog could drive a flock of sheep.—M.D.

‡ This mistake is evidently between the *Clupea alosa* and *Clupea pilchardus*: the former averages about three pounds in weight.

fish being generally the fattest and most vigorous; in fact it is a question if these deeper living fish ever go out of condition except when spawning. The pilchards which hug the land are, however, generally thin and lean, probably with worry from dogfish, whales, and porpoises, and are the first to begin the spring migration westwards and out of the Channel, by taking advantage of the smooth water generally found near shore, and where often an easily caught food exists in the shape of the spores from the olive sea weeds, a few of which are seen in our bays in the early spring.

This migration is altogether different from that of the autumn, being nothing more than a gradual and general move out of the Channel in search of food. A few of these thin and wearied fish may be found as early as the middle of February, off Mevagissey and Falmouth, moving westwards, but the bulk do not put in their appearance until March and April, when they gorge themselves on the spores of these seaweeds—a not very fattening commodity.* Notwithstanding the abundance of this rough food, which is generally found here in these months, these pilchards, however, seem to have a lively remembrance of where they had a better feeding in times past, and yearly move slowly away towards it, putting on a decided western movement, and generally leaving our coasts before the middle of May.

The deeper-living and stronger pilchards, which had been hunting over the narrower portions of the English Channel for food, also begin to move, with the spring months, on western lines, those having parental proclivities passing out much the fastest, for by some strange intuition pilchards with roe in them are always sure to find better feeding than the ordinary fish; unlike the herring, which

* When salted after feeding on these spores, the fish will be found to have a wild seaweed smell with them, altogether unlike the usual pilchard, and are very objectionable as food.

sometimes remains weeks and sometimes months together without eating before spawning time. These pilchards are always found where there is a fair supply of food, and often feed to repletion up to the time of spawning.

In the past season, late in May, large full roed pilchards were plentiful thirty miles south of the Deadman headland; and in June, vast masses, heavy with spawn, were seen from twenty-five to thirty miles south of the Lizard. This is a fair sample of their usual movements, although I have instances of pilchards spawning much nearer land than this. After spawning, when lank and ravenous, if the food near them is not satisfactory (which often it is not), the search for more food begins; and if the entrance to the Channel proves unsatisfactory, then the rush is continued into the Atlantic. Probably the bulk of the pilchards, which had not spawned in the winter, have been left in the English Channel. These also, as the season advances, feel the western stimulation and move on in the same direction. But soon another feature of those surface-living fishes comes into active operation: I refer to their sense of smell, which plays such a wonderful part in their existence. I have reason for believing pilchards can detect food through these organs full twenty or thirty miles away.* With the use

* On the coasts of Cornwall, in the spring months of the year, the spores of the olive seaweeds are thrown off in countless myriads, but they do not develop or show themselves until the seas are of a suitable temperature and all are impregnated by the rain. Then, in a few hours, the whole face of the sea, *near the land first*, changes from its ordinary blue or green to a dead olive colour, caused by the spores having enlarged through this process, from microscopic transparent globules to forms of the size of small rice grains and large shot, at the same time putting on this olive hue. When this happens, though mackerel or pilchards may be ten or twenty miles away, in a few hours they are sure to be on them, feeding ravenously. In 1893—throughout the week beginning with March 6th, our mackerel boats reported masses of Pilchards from 20 to 25 miles from land. These were seen daily until the 13th of March, when the water turned olive along the shore. On the 14th of March, our whole coasts were alive with pilchards, and 150 thousands were landed from only a few boats. While those fishermen who went out where the pilchards had been reported, found none until they returned back to the shore.

M. D.

of this sense, other intuitive conditions present themselves: for where food is present, but not abundant, only sufficient fish will present themselves to feed fairly on it, while where food is excessive, vast masses of fish will soon appear. This feature is particularly seen in the last of these out-going pilchards, for as the summer advances the accumulating larval forms of crabs on the surface of the Devon and Cornish waters are detected. In the olden times, before the railways came westwards, enormous masses of these zoe forms lay along the these shores; and vast masses of these outgoing pilchards turned in here and fed to repletion on them, thus unwittingly holding the balance of the crab life, by eating up the surplus young not necessary for the continuing of the race. The same thing yearly occurs still, but as only a few of these larval forms are found on our coasts now, only a few of the migrating pilchards turn in on these coasts, the bulk following on into the Atlantic or to the deeper water at the entrance of the English Channel.

Their Atlantic food also consists of minute crustacea, mainly belonging to the families of thysanopoda, amphopoda, and copepoda: the first is shrimp-like in form and less than a half-an-inch in length; the other two have an outline not unlike the common flea, hence our fishermen call them such. How far out into the Atlantic pilchards may sometimes have to go, or the extent of the circuit they may have to make, to find this food is not accurately known, but occassionally it is probably not far from the line of soundings. Capt. J. Ball, who for many years has been running a steamer between Spain and Liverpcol, often, in the early autumn, passes over masses of pilchards from fifty to one hundred miles out in the fairway of the English Channel; and Couch mentions vast bodies of pilchards being seen in July, approaching the land 120 miles S.W. of Scilly. I believe these fish were

on their outward rather than on their homeward journey,* as all my collected evidence goes to show that pilchards approaching the Devon and Cornish coasts in the summer months, in the long-past great years of pilchard seining, moved in from the Channel. These facts came from my ancestors, who on my father's and mother's side have, for generations, been Trinity pilots, beside having an interest in the pilchard fishery, and their experience, sustained by the evidence they collected from the ships they piloted, was that the summer pilchards approached Cornwall from the south-east. This is also in keeping with the now known habits of the pilchards.

And now follow some very important facts in connection with the history of our pilchard fishery: We have seen that most of the pilchards which occupied the English Channel in the winter are nearly all moving with the summer into the Atlantic in search of their delicate crustaceous food. If this is found directly in front of the Channel, the pilchards will remain there and feed up to their necessary condition. Then, with the first storms of autumn, the fish with the best developed roe (which will probably spawn in winter in the English Channel) will form into large "schools," and lead the way back into their old haunts, often without touching any of our western seine stations. But should the food in these S.W. waters be unequal to the wants of these fishes, they will take a wide circuit to the N.W., often far outside the Scilly Isles, and after finding sufficient food along the entrance of St. Georges Channel, *or near it*, will, with the first storms of winter, begin their return migrations, into

* When the steam yacht "Theodore" was on her voyage from Belle Isle to Falmouth, she had two practical pilchard fishermen on board. On the morning of the 6th July, 1892 about seventy miles S.S.W. from the Lizard, they first sighted pilchards, which soon appeared in large "schools." It was estimated they went through fish of this kind until within fifty miles of the Lizard. No one can estimate the masses that were passed on this occasion. Evidently they were our outgoing pilchards in search of food, and probably were just like what Couch's friend saw, which he describes as approaching the English Channel.

the English Channel. Dr. Day remarks, on the authority of the St. Ives fishermen, that in October and November, about three days before pilchards visit St. Ives, they are seen off Kinsale, in Ireland.

I can scarcely think, however, these can be the same fish visiting Cornwall, but rather belong to a larger fraternity of pilchards, whose home in winter is the Irish Channel and the Irish Sea, and who, like the English Channel fish, had been roaming the Atlantic, probably on the north-west side of Ireland, and being acted ón by the same storms, are returning, like the English fish, to more quiet waters.* Pilchards visiting St. Ives are often seen by passing vessels some days before, to the west of Lundy Island in large shoals, colouring the sea, often followed by thousands of gulls and gannets, and sometimes by rorqual whales. In an ordinary autumn and early winter, these migrations will be divided into three or four distinct movements, each taking place after a storm, the first as early as the 25th September, the last sometimes in December; but the principal part of this homeward rush is done in October. This migrative act in itself is rather a large one for so small a creature. The homeward journey of the pilchards, if they are to the north of the Scilly Isles, in most instances cannot be less than a two hundred and fifty mile swim. From St. Ives to Mevagissey, with the round of the coasts, is about 65 miles, and this distance is generally covered in three days, or at the rate of twenty miles per day. The wonder is how they are able to sustain themselves in such an effort. After a violent hurricane in October, 1886, the whole body of fish in the outer waters migrated in without a break, and were seven days passing our eastern fishing stations. An early stormy autumn will cause an early

* In the seventeeth century, Ireland had an extensive pilchard fishery, valued at £20,000 per annum. which the Irish allowed to slip through their hands; and as these pilchards were on that coast so long ago, I have reasons for believing that pilchards are as plentiful as ever there now, and that these were the fish noted by Dr. Day.

migration of the pilchard back into the English Channel—hence an early autumn fishing; whereas in a fine autumn, pilchards will remain longer in the Atlantic, and give us a late autumn fishery. Often on the first migration of pilchards into the Channel, all the pilchards which have been feeding throughout the summer on the coasts of Devon and Cornwall, with all the small mackerel, catch this migrative inspiration and rush away with them.

I think it will be now seen that is only when these pilchards in their outward search after food make the circuit of the Scilly Isles, and visit the entrance of the St. Georges Channel and north-west waters, that the north coast seine fishermen have any chance for a successful autumn fishery. When the pilchards go in that direction their habits in migrating are to strike the land on the north side of Cornwall, or at least to come very near it, and then to keep along within knowledge of it until they are around the Land's End and well on into the English Channel, before taking off into deep water. This gives all the seine fishing stations on the Cornish coast a thorough "waking up," but even then the fish may not be caught at any of these places, as fine weather and clean water directly after the gale would cause them to migrate from headland to headland, which is often too deep for the seines unless at spring tides, neap tides favouring the fish swimming in straighter lines.* To sustain these remarks

* The quantity of pilchards caught or missed does not in any way represent the amount or extent of fish migrating into the Channel. Conditions may be unfavourable for the seines, and immense bodies of pilchards may pass without their being able to reach them. When the first enclosure of fish was made at Cadgwith in the autumn of 1888, I was wired to at Mevagissey; we posted on with all speed, and arrived in time to run on the hill about a quarter of an hour before dark. In these few minutes I saw thousands of hogsheads of pilchards pass through the stems, but circumstances were not favourable for the seines. The greatest enclosure of fish in the county in one day was made in 1871, in the autumn migrations. These fish were not travelling with their usual energy, but were simply creeping into the English Channel. They were very thin and much out of condition, and very little better than our spent summer shermers. It was doubtful if they had found their usual summer food.

as to how pilchards in the autumn do and do not visit the St. Ives district, I cannot do better than give some further evidence from the pilchard season of 1890. In July the usual summer fish seemed to come in on the Cornish coasts, but when we expected them off the bays in August, they only made their appearance once, and the next night turned back again into deep water. On putting their stomachs under the microscope, no larval forms of the crabs could be found, but the deeper-living fish had their stomachs full of copepods—*Anomalocena patersonii*. For the whole summer and autumn no fish of any consequence could be caught nearer than eight or ten miles from land, but there was no deep sea limit to the catching of pilchards, all feeding on these crustacea. All these fish were plumper and fatter than any summer's fish I had known for twenty years before; and later on, in the autumn and winter, the pilchards caught at Plymouth gave more oil than any I had ever known.

It must now be observed—and I believe I am safe in saying it—that not a single "school" of pilchards was seen at any seine station for the whole season, and what is stranger still the drift fishermen along the whole coasts of Cornwall throughout the autumn did not notice any in-Channel movements of the fish. But when the season for the English Channel fishery came around, the pilchards were found on their old grounds to the east of Plymouth. All this points to the fact that there was so much food at the mouth of the English Channel, that pilchards had no need to roam over the ocean. Consequently the migrations were only nominal, and, as a result, St. Ives and all the seine stations were without pilchards. As there are some changes in the numbers of summer pilchards visiting our coasts, and observing their habits is not so easy now as in the past, I ought to record some facts I have on

PILCHARDS FEEDING.

When pilchard food is found fairly abundant near shore in the summer months, instinctive habits in the

pilchard at once present themselves to meet the occasion. One phase is that these fishes take the opportunity of forming into "schools" in the daylight, and feed slowly landwards through the food until near its extreme shore limit, where they await the evening twilight to begin their night's work. The point gained in this move, over and above a light meal, is that when feeding in the darkness all semblance of "school" order is lost; but by taking this shore side position and feeding with their heads from the land (which is always done), when the morning comes they are sure to find themselves comparatively near each other, ready again for re-forming into "schools" for mutual protection from their enemies.

If pilchards, on coming in from the sea and finding food near land, waited on the outside of the creatures for darkness to set in to begin work, and then attacked them with their usual vigour—rushing landwards in their mad onslaught—there cannot be the least doubt but that quantities, in the darkness, would rush on to the land, beaches, and shallows of the coast, and much destruction of pilchard life would be the result. Moreover, the bays and other intricacies of the coast line would prevent such as might be uninjured from readily forming into "schools" again with the morning light.

Turning back to the habits of these fishes, when feeding in the day in "schools" on this pioneer work, we find that a rough kind of "law and order" prevails throughout the company, and "live and let live" guides them in their movements through the sea. This is seen in the actions of those fish which compose the outer parts of the "school," who, after having had a decent grip of the passing food, fall back into the centre, by this act allowing other hungry fish to get to the front, who in their turn can have a taste of the dainties. In travelling in the day time through the food to their inshore destination, this change and interchange is continually going on, while order and compactness prevail throughout the "march."

But when evening comes and darkness intervenes, and the continued interchange between night and the luminous glare of the sea is fully set up, then with these fishes the past is forgotten, all order is cast aside, and excitement of the wildest description begins. Like men in the sinking ship—every fish is for itself. Then comes the mad rush in destroying these tiny atoms of the sea. Fishermen often describe it to each other as being like the cliffs falling down, so violent is the nature of the attack, when millions of these pilchards rush forwards, throwing themselves headlong out of the water in this wild feeding orgie.

Another feature in pilchard feeding is that if storms have been long and violent, when the break comes, either in summer or winter, on the first fine evening pilchards will be playing on the surface of the sea—even if it be bright moonlight, when food cannot be discovered. The inference is that at such times they must be playing from sheer enjoyment. But I have something to say on

SARDINES OR SMALL PILCHARDS.

There can be no doubt that all the varieties of large and small pilchards are found on our coasts. Couch states that in the early part of the present century the larger proportion of pilchard "schools" on the coasts were small fish—that is pilchards less than eight inches in length, and from 1835 to 1855, small pilchards frequented our bays in the summer months in countless millions, and were often a nuisance and a pest to our fishermen. When the seines enclosed pilchards, the first question was their size: fish less than eight inches long were useless for exporting purposes, and were generally quickly turned back into the sea again alive, But sometimes in the excitement and darkness of the night the men have been mistaken in the size of the pilchard and have taken them into their boats. Then when the daylight undeceived them, the fish had to be carted off for manure. I have often seen such fish on our piers piled some three or four

feet high awaiting the waggons. There can be no doubt that if in these times we had cured and treated these small fish, as the French were curing and treating theirs, we should now have a sardine fishery superior to the French.

But instead of doing as the French did, in protecting and feeding these young things on their coasts with cod and every other available roe, we ignorantly did the very opposite, and starved them out of our corners and bays, driving into deep water to seek their necessary food. On our own coasts evidently the larval forms of the crabs have been the principal fare of the pilchards, large and small, in the summer months of the year. Some of these crabs have enormous powers of reproduction. In *Cancer pagurus*, or the great crab, there are from eight to ten females to one male, and each female spawns from one to two millions of eggs. These pass through several distinct changes on the surface of the sea—hence on our first outlook we seem in danger of being over-crowded with crabs. But Nature, true to herself, has a means at hand to prevent such a catastrophe in pilchards, young and old, who attack and devour these crabs when in their zoe forms on the surface. Hence in the olden time, when there was no market for the female crabs, there was seldom any lack of these pilchards, large or small, in our bays in the summer months of the year. But since the extension of the railway system, the demand has come for all the crabs, male and female, and, as we have seen, not only have the large pilchards become scarcer and thinner, but the young French sardine-sized fish has almost disappeared.

Still we hold proof that they are not altogether gone; and as the French fishermen by coaxing and extra feeding retain their young pilchards on their coasts; so that the French sardine-sized fish might be again brought back into our bays by treating them kindly as the French do, is, I think, quite possible.* Every autumn we have these

* The French have been known to spend sixty thousand pounds a year in Cod's roe to feed their young Pilchards or Sardines.

countless quantites of small sardines on our coasts, as the result of the spring spawning of the parent fishes, and in October they are about three or four inches long, and so slight that three or four hundred could be easily put in a well-filled pint measure.* These remain off our coasts all the winter, and do not take on the habits of the older fishes until over twelve months old. If these young fish could be taken in hand in a large and generous manner, feeding them freely with cod roe, it would seem possible we might have an extensive sardine fishery on our own coasts. As we undoubtedly have more of the parent fishes than the French, it is only natural to suppose that we must have a larger amount of young fish than they. That our Cornish pilchards will eat cod's roe I have had proof in once going out in our own bay and hanging a few pounds of roe over the boat's side in a basket. In a short time pilchards came around me in thousands, and so tame were they that with a string and a naked hook I could pick them out of the water. I estimated that at one time I had twenty thousand pilchards around the boat.† Mr. Richard Blamey, of Mevagissey, under like conditions found that pilchards would eat crumbs of bread.

That these little pilchards spoken of above, do not leave the deep water of our coasts we have proof in the fact that in dry springs and early summers sardines, of about six inches in length, are often found near shore. In June, 1891, these, for a few days, were plentiful in St. Austell Bay, and in the spring and early summer of 1892,

* All the autumn and winter months, these young pilchards hang about the coasts of Cornwall—the gulls, gannets, gullimots, razor-bills, whitings, and mackerel, feeding on them. The Sardine factory—once with a small seine of ninety rows to the yard—employed men to catch them. The first time the seine was used, some scores of thousands were caught, but the fish were too small for their purpose; eighty of these were put in a quarter box. These when caught were about three months old.

† Between the years of 1860 and 1870, the pilchard seines of Mevagissey did some work with cod's roe, but the success was only partial. I have reason for believing that the distribution of the roe was done too sparingly.

great quantities visited Plymouth harbour, and the Mevagissey Sardine Company—as an experiment—had enough down by land to make over two thousand boxes. Mr. Cunningham tells us that in the autumn he found sardines of about seven inches long off Plymouth, meshed in the Biological anchovy nets.

These facts are enough to show that these little fish still exist in the English Channel, and it would seem that all that is wanted is a master hand to work the matter up to a success.

This question of large and small pilchards, or sardines—judging from remarks in the Plymouth Biological Journal—seems to trouble our French and Italian neighbours; and I am led to believe they have the idea there may be a *shore* and a deep-sea sardine. But I cannot see that these authors have, in any way, altered the decisions of our greatest icthyological authorities—Couch, Day, and Gunther—who each and all state that sardines are only so many small pilchards. In proof of this we have the facts (all other things being equal) that in the summer months the size of the pilchards off any coast will be chiefly governed by the fact that abrupt and exposed coasts, having a heavy sea and violent tides, will have the strongest and largest fish swimming in its waters; while the bays and narrow seas and inlets will have the young, weak, and smallest pilchards in them. I have been led to believe that the bay of Douarnenez is the deepest bay on the coasts of Brittany, and in it is carried on the largest fishery for small pilchards on the French coasts. On the more abrupt parts of the coasts of Spain the pilchards are larger, and in the Italian markets are sometimes able to compete with those of Cornwall. The same law comes out with those fish which remain in the bays near shore in the English Channel in the summer months, as being smaller and weaker fish than those which fearlessly go out and seek their food near our exposed and rocky headlands.

Hence the pilchards of the Mediterranean will be a much smaller fish than those frequenting the Atlantic sea-board. This general law regulates the size of more fishes than pilchards—for the herrings of the Baltic are seldom found above eight or nine inches long; while among the rolling billows of theNorth Atlantic ocean, herrings are often found from twelve to eighteen inches in length. It is also found in full force in still smaller waters than those spoken of. I once tried to rear grey mullet in a glass vessel holding about 2 gallons of water, and everything progressed successfully until the fish got to about four inches long, then no amount of food or forcing could get them above the size mentioned. The same kind of fact also came out in the growth of congers in the Southport Aquarium. In the small tanks the congers would only grow to a few pounds in weight, although kept for years; but in the large tanks prepared for holding the sharks and the cetacea, where the congers had the same amount of food as those in the smaller tanks, they astonished the directors by growing in three years to ninety pounds weight each.

PILCHARD GROWTH.

In the year 1884, at the annual meeting of the Falmouth Polytechnic Society, I exhibited a series of pilchards, showing their growth from the time of their just leaving the egg, in stages on to the full-grown pilchard, for which I received the Society's medal. But I find there is no record of the length or age of those fishes in the Society's *Journal*, and as I have most of them now with the labels on them as exhibited, I beg leave under this heading to set forth the length and ages of these pilchards.

No. 1 exhibit consisted of pilchards less than an inch in length and less than a month old—labelled in August.

No. 2—pilchards about three inches in length and about two months old—labelled late in September.

No. 3—a pilchard about five inches in length and about eight months old—labelled in March.

No. 4—a pilchard six and three-quarter inches in length and about thirteen months old—labelled early in August.

No. 5—a pilchard eight and three-quarter inches long and over two years old—labelled early in August.

In estimating these ages I have taken the later part of June as being the spawning time of the parents of these fishes, and I have given them about a month for the work of hatching into life. It is known, however, that the eggs of herrings hatch out much quicker than this; and it may yet be shown that the time of hatching the pilchard eggs may be much shorter than I have estimated, in which case all these fishes would be a few days older than the time named.

SHERMERS, OR DRY PILCHARDS.

After the summer pilchard fishery has begun about a month or six weeks, these shermers make their appearance along the entire south coasts of Cornwall, close in shore, but are the most plentiful in the nooks and sheltered corners of our bays. They have a large frame, but are a weak, thin, and dry race. They show all the actions in a lesser degree of the stronger fish, and in the evenings feed from the land. Very little is to be seen of them through the night, for they seem too weak for much effort, but they are at their posts feeding offwards again the next evening. Occasionally in the daytime they may be seen in "schools" close to the shore, and our drift boats fish for them in stormy weather when it is difficult to venture far out at sea. Evidently these are the old and spent fish, which, after the summer spawning were not equal to contend in the open sea for their daily food, and hence have turned in here quietly to pay the debt of Nature. They do not migrate into the English Channel in the

autumn, like all other pilchards, but simply hang about these corners until the end. I have seen some as late as December in the bays. In the year 1890, when copepods were plentiful off our coasts, no shermers visited the Cornish coasts to the east of the Lizard for the season.

PILCHARDS SLEEPING.

It has been argued by some writers that fishes do not sleep, and in proof they cite the case of sharks and pilot fishes following ships for days and nights in succession without resting. As a set off—the probability may be urged of these fishes sleeping one eye at a time,—in some of the fishes I have observed the volitions of the will are very different from those in man—with one eye they can look forwards, and with the other backwards, or upwards, and downwards at the same moment, if it suits their purpose—or they can keep one eye at rest, and the other active; of course the inference is that fish have the same power over all the senses and can rest one at a time if needed. But that some other fishes rest all the senses at once, I think there can be no doubt. I once found some blenny spawn, from which I hatched out some hundreds of young fish, which proved to be very lively little creatures, and, unlike their parents, swam in mid-water. I kept them in a large glass globe on my study table. When they were about two days old I lost sight of their active forms, and on carefully looking, found them apparently dead at the bottom. I took a large knife and stirred the contents. All was in motion, but the fish appeared only as a part of the inanimate water—as limp as rags—some being lifted to the surface by the circulating motion. Then I left them for some hours, and on again coming into the room, I was surprised to find the little fellows as active and busy as ever. On carefully observing them, I then found they had long hours of slumber, which no stirring of the water could disturb; but the sleep did not appear to be taken at regular intervals. That pilchards sleep, I think I can

bring good proof. Mr. Joseph Body, an old pilchard seiner, saw a small school of pilchards sleeping in the sunshine in a seine in Mevagissey Bay, lying in the shallow water their sides on the sand, and not easily disturbed. Again, in waters where pilchard food is plentiful, and the enemies of the pilchard are small, but persistent—such as bream, whiting, and small congers—and rest is not allowed them at the bottom of the sea, the pilchards may be seen sleeping in the daytime on the surface of the sea in shoals, lying on their sides, the whole mass having the appearance of one vast sheet of silver resting quietly—just under the surface, in the sunshine, the metallic sheen is most decided, and could be distinguished full one hundred yards away. At such times boats can approach close to them before they will resume their upright position. I have seen this side of pilchard life many times, and fishermen in reporting the fact to each other state where they have seen some "lattice" fish,—lattice being a local name for tin plate, or some other shining matter.

PILCHARDS "BUBBLING."

I do not see this mentioned by any naturalist as connected with the history of the pilchard, but it is a feature continually coming out when pilchards are moving quickly in large bodies. I never heard of it as being seen with any other fish, but it is always sought for by fishermen pursuing pilchards. At such times thousands of strings of bubbles, each about the size of common peas, may be found coming up from the depths, when vast quantities of the fish are below.

FREAKS.

Often in the spring months of the year, single pilchards may be seen along the coast close to the shore; they have all the appearance of having lost themselves, roaming like a dog without its master, having an intense restlessness and swimming continuously without any design.

On the least fright they will rush on to the shore and destroy themselves. Not long ago I saw a pilchard in this state fall in with eight or ten trout (*Salmo cornubiensis*), which came from the mill stream into our harbour; instantly he turned in with them, ceased his violent exercise, and became as one of the party, suiting his actions to their lines, and continuing with them for some days.

Again, pilchards will eat many forms of minute life—spores of seaweeds, minute medusa, midges, &c., but on September 3rd, 1889, I fell in with a rare gourmand, which had in his stomach forty young fishes, of three distinct species. Easily distinguished were the crystal gobies, so plentiful off the Deadman, and young launces. The third species seemed very much like young pilchards; if this was so, beside being a glutton he was a cannibal.

AN ALBINO.

In September, 1889, a rare pilchard was found among some thirty thousand others in the sardine factory at Mevagissey. The jaws and entire snout were of the usual albino colour, beginning at the base with a slight orange tinge, and ending in a decided white at the end of the nose. The rings around the eyes were slightly red, and all the fins and tail began with a light yellow in the body and ended in white at the tips. In fact the whole fish throughout had a decided whiteish metallic lustre instead of the usual white and blue.

HYBRIDS,

As mentioned in my essay in 1887, have been still plentiful here, and are still exciting some curiosity in the scientific world. Mr. W. Bateson, of the Cambridge University, in a paper read before the Zoological Society, considers them as belonging to fishes having multiplication of parts, and not to the hybrids; classing them with crabs and lobsters having extra nippers and legs.

PILCHARDS AS FOOD.

In the year 1883, at the time of the London International Fishery Exhibition, some of the American Fishery Commissioners—among them Profesor Brown Goode, and Mr. J. W. Collins—visited Mevagissey, and tested the pilchard on its food qualities. Their opinion was that it could assimilate with a greater variety of condiments than almost any known fish; and that it might be made the *base* for building up almost any dish suitable to the appetite of the epicure. Since then a portion of this opinion has been curiously verified, as given on the authority of Capt. J. Farren, of Mevagissey.

Not long since a cousin of Her Majesty visited a county family in Cornwall. In making the necessary preparations for his reception, earth and air were helpful and propitious, but the sea refused her usual bounty. "What?" said the astonished French cook, "is there no fish, fresh or salt, to be had in Mevagissey?" "No," replied the Captain, "we have nothing there but salt pilchards." "Pil—chards! pil—chards!" exclaimed the Frenchman, not knowing them by that name. "Sardines" said the Captain, endeavouring to enlighten the cook's mind as to what they were. "Oh," shouted the Frenchman, "it's all I want, get me fifty." On the evening of the dinner, "white fish from the Lake of Geneva" went the rounds of the table; and shortly after Capt. Farren was thanked by the head of the house for assisting his cook in getting such nice fish from so far away for his distinguished guest.

LECTURE 10.

(Delivered on Friday, August 11th, 1893.)

COLOUR BLINDNESS:

Its Dangers and Detection.

BY

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Chairman:—JONATHAN RASHLEIGH, ESQ.

COLOUR BLINDNESS: ITS DANGERS AND DETECTION.

The Chairman, in introducing the Lecturer, said he was a gentleman who paid great attention to the question of Colour Blindness, which was becoming more and more important every-day. It was to be regretted that the Government did not, in earlier days, take up the subject, for serious accidents had occurred on the railways, in consequence of the authorities not knowing that those having to do with the signals were colour-blind. They had paid some attention to it in regard to the navy, and he (the Chairman) considered it of the utmost importance that tests should be made such as would insure that no one having to do with lights either on the railways or on board ship should be afflicted with this malady. (Applause).

Mr. Bickerton said—Ladies and Gentlemen, I am glad to have the opportunity of bringing before your notice, a subject, which until quite recent times, has been too much neglected by the public, and if I fail to arouse your attention, the blame will be entirely mine. It is a subject of most absorbing interest, and while it has but a general bearing on our every day life, it has had and still has a direct and most baneful influence upon the lives and homes of our seafaring population. To you, whose shores are washed on three sides by the ocean, and whose population has in the past furnished so large a contingent to the Mercantile Marine of this great country, the defect of colour blindness, whether you are aware of it or not, must have had a disastrous influence on

your prosperity. In order to comprehend thoroughly what is meant by the word "colour blindness" it is essential that we should know first what is understood by the word "colour," and second, how colours are seen by the colour perfect individual, and although many of you understand the physiology of colour, just as well as I do, I must ask your favour for briefly running over a necessary and elementary part of the subject. It is commonly believed that we see with our eyes. This is only a part of the truth. We really see with our brain. The eye is but the servant of the brain, constructed to photograph perfect images of outside objects and to receive and respond to the vibrations of light. Here is a diagram of an eye. The cornea or window lets in light. The lens is engaged in focussing images of outside objects, from early morn to last thing at night, and lining the whole of the posterior surface of the globe, is the delicately formed retina, which is as constantly receiving the impressions and transmitting them by means of the optic nerve, the telegraphic wire as it were, to the brain, where the messages are registered and converted into the conscious sensations of colour and light. What is light? Just as sound is produced by the vibrations of waves of air or ether striking the drum of the ear, so the sensation of light is produced by the impinging on the retina, of waves of ether projected with immense velocity from the stars above, or indeed from every luminous point, and vibrating with marvellous rapidity. Up to Sir Isaac Newton's time, light was considered to be a simple homogeneous body, but he taught us that the pure ray of light is composed of several brilliant colours. If a ray of pure sunlight be passed through a prism and thrown on to a screen opposite, seven different colours will appear, and in the following order: red, orange, yellow, green, blue, violet, and indigo. If these coloured rays are then allowed to fall upon a double convex lens, they pass through it and converging to a focus, again appear as a white light. Thus what we see and call white light really consists of a combination of many coloured lights.

The pitch of a musical note depends upon the rapidity of its vibrations, or in other words, on the length of its waves. Now the pitch of a note answers to the colour of light, and just as we have many different notes, so we have many different colours. The waves of light vibrate in waves of different lengths and of different rapidities, and thus we have at one end of the spectrum, the colour red, which is produced by the slowest vibrations, at the other end violet, which is produced by the most rapid vibrations, and between these two colours lie all the other colours, each produced by a difference in the vibrations of the ether. The vibrations of the violet, are about twice as rapid as those of the red, and it has been calculated by mathematicians that the vibrations necessary in order to produce white light, are five hundred millions of millions in a second of time, to produce the sensation of red, four hundred and eighty-two millions of millions, of yellow, five hundred and forty-two millions of millions, and of violet, seven hundred and seven millions of millions. When, therefore, colour is talked of, it should be borne in mind, that colour independent of the eye—just as sound independent of the ear—does not exist in nature. Both objectively, are simply vibrations of ether, which our eyes and our ears receiving, are converted through nervous action into the subjective sensations of colour and sound.

It may be very difficult to realise when we look at the myriads of coloured objects around and about us on every side, that the colour of any particular object, animal, vegetable, or mineral, is no part of the object itself, but is due simply and solely to the property or power which the intimate particles of the object have, of absorbing and reflecting the rays of light. Such however is the fact, and it should be borne in mind, that the colour an object takes, is due to those elements of light which are not absorbed, but which emerge and affect the eye of the beholder. For example—the colour black is caused by the absorption by the object of all the constituents of light so that nothing reaches the eye. Red is produced by

the absorption of all the rays but red, the sensation given is therefore red. Herbage appears to absorb all the portions of the rays except green, this it reflects, therefore herbage seems to the eye of a green colour. That colour is no essential part of plants, or other objects may easily be proved. A geranium or red tulip appears red because it absorbs all the colours of the rays except red, hence its colour, but if it be held under a piece of green glass it will appear black, because the only rays which the geranium reflects, viz: red, are now absorbed by the green glass. The scarlet of the poppy, the yellow of the daffodil, and the blue of the violet, are owing to their absorbing respectively all the rays excepting the red, the yellow, and the blue. Transparency is due to all the rays passing through a body without any absorption, while the colour white is produced when all the rays are reflected irregularly, thus milk, white hair, white feathers, snow, &c., are white because of the countless oil globules or bubbles of gas which scatter the light in every direction.

In those most charming essays incorporated in "Fragments of Science" which I would strongly urge all present to read, if they have not done so already, Professor Tyndall shows us, that the colour of the sea is green, blue-green, blue or indigo, according to the amount of solid matter suspended in the water, and also to the depth of the water. The greater the depth the darker the hue. He says "As the solar beam plunges deeper into the sea, orange follows red, yellow follows orange, green follows yellow, the various shades of blue, where the water is deep enough. follow green. Absolute Extinction of the solar beam would be the consequence if the water were deep and uniform. If it contained no suspended matter, such water would be as black as ink. A reflected glimmer of ordinary light would reach us from its surface as it would from the surface of actual ink, but no light, hence no colour, would reach us from the body of the water."

Again, as showing that colour is not a real part of an object is the fact, that the colour of any object varies according to the quality of the light by which it is viewed. No lady would attempt to choose or match a ribbon, nor artist attempt to paint a picture by gas or candle light, and if we were to take a number of pieces of differently coloured paper, examine them by the bright light of the moon and write on the back of each the colour it appeared to be, we should be surprised in daylight to find how much we had been deceived.

Now up to the year 1794, to say that an individual possessed the sense of sight was tantamount, also to saying that he possessed the sense of colour, the latter being considered an integral part of the former, but when in that year the distinguished chemist Dalton, published a graphic description of his sense of colour, the scientific world was surprised to find that there existed individuals whose perception of colour differed in an extraordinary way from that of their own. Further investigation fully confirmed his views, and established beyond all doubt, that the two senses—that of sight and of colour—were separate and distinct, and that while an individual might have a perfect appreciation of form, he might be quite unable to perceive any difference between two or more distinct and different colours.

The normal eye would appear capable of analysing white light into three coloured elements, one of which is red; the colour blind eye on the other hand, analyzes white light into two elements, neither of which is red. We know that even the eye of a perfect colour-sighted man presents at some parts the very condition met with in a colour blind man in all parts. At the centre of the retina (Macula) and for some distance around it we know that the retina can distinguish all the colours of the spectrum, as we pass away from the centre towards the periphery, we come to a zone where the colour green cannot be distinguished, a little further still, red is undistinguishable, then yellow, next blue, and finally we come to an area where no colour, but only light and shade can be made out—a region of total colour blindness.

Blindness for colours therefore may be total—a condition rarely met with, in which the individual sees all colours simply as shades of black and white, or partial, one or two colours only being indistinguishable. Under this head are classed those blind to red, red-blinds, those blind to green, green-blinds, and those blind to violet, violet-blinds, or again the colour blindness may be slight, no one colour being absent, but the acuteness for all colours, or some colours being more or less impaired.

For many years after Dalton's discovery, the subject of colour blindness was one which attracted the attention of scientific men alone, and though one or two voices were raised to draw attention to the important bearing this defect might have upon our general well being, no notice was taken, and it is only within the last few years, that it has begun to receive the attention it deserves, The prejudice which at one time existed to believing that there was such a condition as short sight, and which took many years to overcome, has been exhibited in a most virulent form for years past, in respect to the defect of colour blindness. All sorts and conditions of men have ridiculed the possibility of it, and it has had in addition the powerful voice of the ladies raised against it. But facts are stubborn things, and slowly but surely the public at large are recognising not only that there is such a condition, but that its prompt and early recognition is imperative not only to the individual himself, but to the well-being of the community in which he lives. It is established beyond cavil that from 3 to 4 p.c. of the male population are more or less colour blind, while not more—even if so many—than 1 woman in every 1,000 is colour blind. The great disparity between the numbers of the colour blinds in the two sexes has been long known, and many reasons have been laid down as accounting for it. Possibly the true explanation is to be found, in the fact that females have more practice in the handling of colours than males, and the present immunity which females now enjoy from this defect, is due to the gradual development and

training transmitted through ages of time. The superior colour vision of the female must be regarded as an inherent quality of the sex which no amount of artificial training and practice can attain to, and this of course accounts for the infinitely better colour taste shown by our lady friends. This view is also borne out by the fact that among the American Indians, whose fondness for colours is great, Dr. Webster Fox found only 1·81 p.c. colour blind, while Drs. Blade and Franklin found but $0\cdot\frac{7}{8}$ of the Pawnee, Cheyenne, and Pottawatomie Tribes defective.

We now pass on to enquire what do the colour-blind see? Does red look green to them, or green red, or yellow blue? and in order to better appreciate the colour sight of a colour-blind man, it will be advisable to first demonstrate the mistakes which a colour-blind man makes. If from a large number of differently coloured wools, a pale green skein is selected, and we were asked to choose from the heap all the skeins which had in them any tint of green, 96 out of every hundred would pick out to the very last, every skein which had in it any tint of green however delicate, but this would not be the case with the remaining 4. They would be absolutely unable to do this, but would in addition to choosing some greens, select skeins of grey, yellow, or red to match with the green. This board shows better than I can describe the colours which a seafaring man who had been going to sea for some 20 years chose to match the pale green which you here see. On giving this man a rose-coloured skein—which is composed of a mixture of red and blue in the proportion of 2 to 1—he chose as good matches to it, the colours you see here, viz: blues and purples, and on asking him to match this brilliant scarlet, he chose dark green and brown as accurate matches. This man is typically blind for red. On these other two cards, you will see a slight variation in the colours chosen by an officer in the mercantile marine. He selected to match the rose colour, blue greens, and matched the bright scarlet with light greens and light browns. This gentleman is a typical green colour-blind. On this

remaining card, I have arranged the colours which a violet-blind man would select on attempting to match the rose test, but as this form of defect is rare, and it is of no practical importance, in my further remarks it may be understood that I refer to the more frequent and important forms of colour-blindness, the inability to see red and green. We are now in a position to answer the question: what do the colour-blind see? Well, a colour-blind neither sees red, nor does he see green. This is proved by the mistakes he makes. If a man matches red with green, and both with brown, it is evident that he sees both the red and the green as a brown.

You will probably say: if this is the case, how comes it that the mistakes of colour-blinds are not oftener noticed? For the simple reason that when they occur they are put down to carelessness. The drawings which I have here, were painted by a lad of 7 or 8 years of age. You will see the glaring mistakes made, red being over and over painted in instead of green, and vice versa. But no notice was taken of these mistakes, and it was not until 10 years later when the youth was choosing his profession, that his defect was accidentally discovered Colour-blind people do not of themselves realize their condition. They cannot tell that there is any difference between red and green as they see them, and red and green as viewed by the normal eye. Never having seen from birth any differently, they believe all see as they see. If they knew that they mistook red for green, and both for brown, they would not be colour-blind. We can imagine no colour-blind person prayerfully quoting the well known lines:

> **" O wad some power the Giftie gie us,**
> **To see ourselves as others see us,**
> **It wad from monie a blunder free us,**
> **An' foolish notion."**

For to realize that one is colour-blind, is to cease to be so. It is interesting in this particular, to read part of Dalton's description of his sense of colour, "The colour of a florid complexion he says seems dull, opaque, blackish-blue upon a

white ground. Diluted black ink on white paper gives a colour much resembling a florid complexion. It has no resemblance to the colour of blood. Blood appears not unlike that colour called bottle green, grass appears a very little different from red. The face of a laurel leaf is a good match to a stick of sealing wax, and the back of the leaf answers to the lighter red of wafers. Green woollen cloth, such as is used to cover tables, appears of a dull brownish red colour, a mixture of two parts mud, and one red would come near it; it resembles a red soil just turned up by the plough. When this kind of cloth loses its colour as other people say, and turns yellow, then it appears to me a pleasant green. Very light green paper, silks, &c., is white to me. Blue is the same to me as to other people, both by day and candle light. My idea of brown I obtain from a piece of white paper heated almost to ignition; this colour by daylight seems to have a great affinity to green. Browns seem to me very diversified, some I should call red; dark brown cloth I should call black, and so on." An interesting account is given of the difficulties attending the presentation of Dalton at Court. "Firstly, he was a Quaker and would not wear the sword which is an indispensable appendage of ordinary court dress; secondly, the robe of a doctor of civil laws was known to be objectionable on account of its colour—scarlet—one forbidden to Quakers. But it was recollected that he was colour-blind, and as the cherries and leaves of a cherry tree were to him of the same colour, the scarlet gown would present no extraordinary appearance to him. So perfect was his colour-blindness, that this most modest and simple of men, after having received the doctor's gown at Oxford, actually wore it for several days in happy unconsciousness of the effect he produced on the street."

*"The mistakes made in every day life by colour-blinds may be multiplied without number. A post office clerk in Prussia, was found to be constantly in trouble with the stamps. The accounts would come wrong; sometimes there

* *Joy Jefferys on Colour Blindness.*

was not enough money in return for stamps sold, and on other occasions there was too much. This made dishonesty on his part less likely, but it was incomprehensible how he could make the accounts so entangled. At last it was discovered he was colour-blind, and could not distinguish red from green stamps. An architect was obliged to release a pupil apprentice in consequence of finding him copy a brown house in bluish green paint, the sky rose colour, and roses blue, while an upholsterer having been directed to cover a leg rest in green leather, used a skin of bright red leather. Upon enquiry, it was found he could only distinguish colours in their intensity, all appearing as different shades of grey. He had been in the business several years, having to do with coloured materials every day, but until he found out the defect in his vision in the way described, he was quite ignorant of the fact. But in at least one profession, this possession of this defect is an advantage. A colour-blind engraver writes: "Strange as it may appear, my defective sight is a useful and valuable quality. The only colours I have to deal in are white and black. Now when I look at a picture, I see it only in black and white, or light and shade, and my want of harmony in the colouring of a picture, is immediately made manifest by a corresponding discord in the arrangement of its light and shade, or as artists term it, effect. I find at times many of my brother engravers in doubt how to translate certain colours of pictures, which to me are matters of certainty and ease. Thus to me it is valuable."

In the majority of occupations, it matters little whether a person is colour-blind or not. On the other hand there are some occupations where a perfect colour perception is essential, and I refer now to the two classes—sailors, and those employed on the railroads. All will agree that individuals employed in either of these positions should possess in its highest degree the colour sense, and that the colour-blind in their own interests as well as in those of others, should be excluded from employments, the duties of which they are unfit to discharge. I say unhesitatingly, that in the

past and at the present time, the tests employed on most of our English Railways to detect colour-blindness among the officials, have been and are, misleading to the last degree. They are calculated to lead to the imputation of colour-blindness where it does not exist, and to leave it undiscovered where it does. Recent enquiries have shown that each separate company has a test of its own; most of the tests are next to useless, and the testing is in the majority of cases carried out by incompetent persons. Among the tests employed, are to be found boards with four or six colours painted in a definite position, pieces of cardboard with four colours, coloured glssses and papers, tubes, flags, and a variety of other more or less useless contrivances. Apart from the worthlessness of most of the tests used, there is no guarantee whatever that the examiners themselves are not colour-blind. It is not perhaps quite clear, why a railway clerk, an inspector, or a superintendent, should be considered a competent authority on colour-blindness, yet some of the companies entrust those officials with the responsible duty of testing the colour-vision of their servants. As there are a few remaining sceptics who doubt the fact that railway accidents have been caused by colour-blindness, I give the following record cases:

1—An engine driver on one of our railways, confessed after an accident, through his not distinguishing the red signal, that he had gradually lost his colour power, which had been perfect, and so sensible was he of his loss, that before the accident, he had determined to give up his situation as driver. "Haynes Walton on diseases of the eyes, 3rd ed., page 1052: This is most probably a case of colour-blindness induced by excessive smoking."

2—An instructive case happened lately in Indiana. "A locomotive ran past a danger signal, while the fireman was on the look-out. A collision followed, and the engineer was injured to such an extent that amputation of both legs became necessary. The fireman was found to be colour-blind. A

suit against the company by the engineer was threatened, on the ground that even at common law they were liable for their negligence in employing a colour-blind fireman, and they settled the case by paying the engineer 10,000 dollars."—*Boston Transcript*, *U.S.A.*

3—Dr. Gintl, chief inspector of one of the Austrian railroads, obtained the report of an accident due to colour-blindness, on the Finnish Road, between Helsingfors and Tavastchus, in July, 1876. "It was caused by a colour-blind switch tender showing a green instead of a red light to the approaching train."—Joy Jefferies on colour-blindness, 2nd ed.

4—"I have been on the railway for three years, and had a mate who could not tell a red from a green light at night in a bit of fog, and "we had a pitch into another train over it."—Letter by a "Thirty-years Railway Man." Invention, Dec. 28th, 1889.

5—"Some years ago, a collision occurred on a railway in consequence of a train over-running a signal; the driver was firm in his statement that the light was green, whereas all the other men said it was red. The driver was fined, and afterwards continued at work as usual. He then made some mistakes, which would have ended in collision had not the fireman said "stop mate." Without any cause being stated the driver decided to give up railway work, and take to another occupation."—Letter by Mr. Stretton, published in Engineer, Dec. 6th, 1889.

6—Dr. Minder, in Berne, reports among his cases, "that of a very intelligent young man who was red-blind, but was not aware of it. He held the position first of fireman, and then of engineer, on one of the Swiss roads. He was hardly at work before his defect troubled him. Thinking it was due to the spirits he drank, he stopped this for a while, but, the trouble continuing, he became convinced that "something was wrong with him about the colours," and left the distinguishing the signals to his normal-eyed

assistant. When another man took this assistant's place—who also seemed to have been colour-blind—the work began to be uncomfortable. As our red-blind engineer now had no control by his side, and very frequently was mistaken in his decision, there occurred a series of mistakes, fortunately only whilst manœuvring in the stations, which brought him occasional fines, and other disagreeable consequences."—Joy Jefferies on colour-blindness, 1 ed., page 152.

Serious as colour-blindness is in a railway official, the dangers incurred owing to it are fortunately at the present time greatly minimised by many considerations. The fact that there is a test, however bad it may be, will keep away most if not all colour-blind men who are aware of their defect. Then a railway man is associated with coloured signals, morning, noon, and night, and his actions are governed by these signals in conjunction with a number of other officials. If his vision for colour differs with that of his associates, he soon becomes aware of the fact, and while not openly admitting his defect he admits it to himself, and finds a reason for leaving the service. The extension of the block system, the presence on the engine of two individuals, and the fact that before a driver is entrusted with a train, he is taken over the ground many times, and every light carefully pointed out to him, all tend in this direction. If a light did not appear where it was expected, the driver would naturally ask the fireman to aid in the look-out. It must also be remembered that to over-run a danger signal does not of necessity imply a collision, a driver may over-run a signal, and after doing so may see a train or other obstruction in time to avoid an accident. In such a case he would probably be reported and fined for over-running a signal, and if the same thing occurred again, he would be dismissed for his assumed carelessness. Colour-blind firemen are unquestionably thus driven out of the service, by the complaints of their drivers, and none but railway officials know how many cases of over-running signals, followed by disputes as to what the signals actually were, occur in the course of a year's work.

The risks incurred by the employment in the mercantile marine of colour-blind officers and look-outs, are terrible to contemplate, yet, and I say it with full consciousness of the seriousness of the statement, there are hundreds of men sailing the seas to-day who are incapable of distinguishing with certainty between the port and the starboard light of a vessel. There is no test whatever as to a sailor's sight. He has only to do with lights when alone on the look-out, and there is therefore no chance if he makes a mistake of its being pointed out to him, as is the case on the railroad by a companion. Then he is not required to state whether it is a green or a red light, he has only to report "a light." Thus his colour vision is never called in question, at least not until he gets into the law courts to be asked the foolish question, are you colour-blind? to which he naturally replies "No." Thus colour-blind sailors do not as colour-blind railway men do; discover their defect and leave the service. Again trains run on definite lines, whereas the ship is a free agent and ploughs the sea in any and every direction. At any moment a signal light may flash ahead or astern, on the port or the starboard bow. In other words, the engine driver is always on the look-out for the expected, the sailor for the unexpected. For these and other reasons, the subject of colour-blindness as it affects the mercantile marine, has always appeared to me a much more serious matter than as it affects the railway service, and I do not believe, that even the most stringent regulations respecting colour-blind railway men, would have one tittle of the effect they themselves fear. None the less is it necessary that they should be discovered and removed to positions in which their defect would be no obstacle to higher promotion. No such hopes can be held out to colour-blind sailors. They must be absolutely debarred from the sea life.

Let us now see what has been done to attain this absolutely necessary end. I am very sorry to say that the Government of this great country has been deplorably, and

in my opinion, criminally lax in this matter. Until the year 1852, there were no definite rules regarding the carrying of lights at night by vessels at sea, but in that year the following regulations became law. Between sunset and sunrise, a bright white light is to appear on the foremast head (steamer), a green light on the starboard side, and a red light on the port side. The lights are to be guarded by screens, at least three feet long, to prevent them from being seen across the bow, and the expectation, as stated in the official notice, is that the effect of the arrangement proposed will be such, "that in any situation in which two vessels may approach each other in the dark, the coloured lights will instantly indicate to both, the relative course of each, that is, each will know whether the other is approaching directly, or crossing the bows either to starboard or to port. This intimation is all that is required to enable vessels to pass each other in the darkest night with almost equal safety as in broad day, and for the want of which, so many lamentable accidents have occurred." At this time, the subject of colour-blindness had not awakened the attention of practical observers, but three years later, in the year 1855, Dr. George Wilson of Edinburgh, a distinguished member of the medical profession, published an excellent work, entitled 'Researches on Colour-Blindness.' He showed with the greatest clearness, how the safety of a vessel lay in the hands of men, look-outs, officers, and pilots, who might be colour-blind but unconscious of their defect, or afraid to confess it, and he came to the definite conclusion, that as the colour-blind are in a minority in the community, therefore those destined to deal with signals should be selected solely from the majority whose vision was normal. I cannot do better than quote his almost last paragraph: "The professions for which colour-blindness most seriously disqualifies are those of the sailor and railway servant, who have daily to peril human life and property on the indication which a coloured light or flag seem to give. Fortunately a ship is seldom under the guidance of a single person, and in Her Majesty's vessels the colour signal men are selected

from a large number, and are ascertained to have a quick eye for colour. In merchant ships, the choice must necessarily be made from a much smaller number, and the appalling yearly list of lost vessels which appear in our wreck returns awakens the suspicion that more than one of these fatal disasters may have resulted from the mistaken colour of a lighthouse beacon or harbour lamp, which on a strange coast, and with perhaps the accompaniments of a snow-storm or a thick fog, has been wrongly deciphered by a colour-blind pilot."

The condition of affairs was this: The authorities believing that the want of coloured lights at night at sea, had led to so many lamentable accidents, insisted on coloured lights being carried by all vessels at sea at night, in order to prevent collisions. Dr. Wilson pointed out that since there existed individuals afflicted with a physical defect known as colour-blindness, a condition in which, while the vision for form may be perfect, no certain distinction can be made between the colours red and green, therefore to such men, the exhibition of coloured lights (red and green) by vessels at night could convey no correct significance, and in consequence be no safeguard against collision. He also demonstrated how these colour-blind men were not only unable to detect danger when present, but how they actually created danger otherwise not present, and he urged that unless all colour-blind men were excluded from the position of officer (captain, first, second, and third mate), pilot, and "look-out," the system was fraught with unsuspected danger to all who trusted in it. In the face of this and other protests by those entitled to give an opinion, ignorance, apathy or rank carelessness, carried the day, and it was not until 22 years later, viz: in 1877, that the Board of Trade recognised that there was such a defect as colour-blindness; even then it was not of their own free will, but because they were forced into action by public opinion. In the December of 1876, a serious railway collision, resulting in five deaths and thirty

injured, took place at Arlsey Junction. A letter was written to the Times, suggesting colour-blindness on the part of the engine-driver as the possible cause of the disaster, and this, which was the first letter on colour-blindness ever published in the Times, was followed by many others, and the Whitehall authorities awoke from their long sleep of indifference, and at last grasped the fact that there was such a defect as colour-blindness, and admitted "that the serious consequences which might arise from an officer of any vessel being unable to distinguish the colour of the lights and flags which were carried by vessels, necessitated all candidates for examination for masters' or mates' certificates passing a test examination as to their ability to distinguish the following colours, which enter largely into the combinations of signals by day or night used at sea, namely: black, white, red, green, yellow and blue."

Tests and regulations were framed with the ostensible purpose of guarding against those serious consequences spoken of, I say ostensible, for it might be supposed—and without any great stretch of the imagination—that the tests were devised to detect colour-blindness, while the regulations were framed to exclude the detected colour-blind men from the sea profession. Such an idea would be, however, very wide of the mark, for nothing appears further from the intentions of the Board of Trade officials than that. The tests which consist in requiring candidates for certificates to name correctly special coloured cards and lights are based on a wrong principle, and allow scores of colour men to pass, while the regulations do not apply to colour-blind pilots, colour-blind look-outs, colour-blind A.B.'s, and colour-blind apprentices, and do not prevent colour-blind officers from eventually obtaining unendorsed certificates. A test for colour vision to be reliable must be based on the comparison of colours, and the simplest and most efficient in the hands of a competent examiner is that which goes by the name of

Holmgren's Wool test. To name colours may be a test of a man's education, it is not a test of a man's colour vision. An educated colour-blind may, and often does, succeed in guessing the names correctly. According to the Board of Trade, this colour-blind man is not colour-blind, and receiving his certificate, he becomes more dangerous to the community than ever, for his defective colour sense is thus authoritatively whitewashed. On the other hand, an uneducated man with a perfect appreciation of colours, though ignorant of their names, would be, according their rules, colour-blind.

If you doubt this statement, read the Board of Trade Reports for yourselves. You will find by the report of 1885, that out of 85 colour-blind men as recognised by the Board of Trade tests, 31 eventually obtained unendorsed certificates; by the report of 1887, out of 127 colour-blinds, at least 14 eventually received unendorsed certificates; by the report of 1888, of 66 colour-blinds, 4 received unendorsed certificates, a total of 45. Now as colour-blindness, except in rare cases, is congential and incurable, there at least 45 officers who were either not colour-blind when rejected, or who are colour-blind to-day. Which of the two conditions is the more likely one may be gathered from the fact that of these 45 legalised non-colour-blind officers, according to the Board of Trade's own showing, 4, at one time or other, were unable to distinguish red from green, 22 more called red green, 5 others called green red, and the remainder made mistakes of a marked character. If further proof of the worthlessness of the Board of Trade's present tests and regulations is required, it is to be found in a letter written by Captain John Smith, of 7, Winslow Street, Walton, Liverpool, to the Shipping and Mercantile Gazette, and Lloyd's List, dated 13th August, 1889, which reads thus:

"On 19th of June, you were good enough to insert in your valuable paper a letter written by me on colour-blindness, and I am pleased to find that my letter and your

article commenting on same, has attracted considerable interest, notably by the Board of Trade. My object in again troubling you, is to impress upon the Board of Trade the necessity for a more perfect means of testing sight. I have lost my position as Chief Officer in the employ of one of the best and most influential firms in this port, in whose service I had been for a period of six and a half years, and with a near prospect of command, through not being able to conform to owners' rule, and produce a colour test certificate from their examiner, who, on the contrary, styled me colour-blind. I, however, doubted the accuracy of the report, and presented myself to an oculist, but found alas, the company's examiners' report too true. Now, I call this a very painful case, after being thrice passed by the Board of Trade for second, first, and master's certificates. If the Board of Trade examination on any of these occasions had been true, I would have directed my energies towards another way other than the sea to obtain my livelihood.

I may say that the defect in my vision has been, in the oculist's opinion, there from birth. I am now morally and conscientiously, incapable of performing the duties of an officer on board ship at sea, though my certificate bears no endorsement of any kind by the Board of Trade. Many owners I know do not require their officers to pass the colour test, being satisfied with the Board of Trade certificate. But I should think my case ought to be a warning to shipowners not to place reliance on the present Board of Trade test. My colour-blindness has destroyed my means of livelihood, and I fearlessly say that the Government test of sight is to blame for this. I am informed that I cannot claim compensation from the Board of Trade, because they have not interfered with my certificate; but suppose I follow my vocation and get into collision through my defect, what then? and who would be to blame? I am a young man of 33, and have a wife and family depending upon me, and my position at present is very distressing.

The best part of my life (Captain Smith has been at sea for twenty years) has been passed in useless toil. My energies and prospects for the future have been unrewarded and blighted through no fault of my own, but through the lax and imperfect way in which I was examined and passed in sight by the test that was adopted by the Board of Trade throughout the whole of my examinations."

For some years I laboured in vain to induce the Board of Trade officers to improve their tests and regulations, but I might as well have attempted to move the Great Pyramid. I therefore changed my tactics, and laid the subject before Dr. Farquharson, M.P. for Aberdeenshire. This gentleman, to whom great credit is due, at once brought the matter before Parliament. The public press seeing the importance of it, took it up, and the Board of Trade has again been compelled to move, though I regret to see the movement is slow. It is now more than twelve months since the Report of the Committee on Colour-Blindness appointed by the Council of the Royal Society was laid before Parliament, and still no official change has been made either in the rules or regulations.

Colour-blind men still enter the Mercantile Marine, to furnish in good time their contribution to the wreck reports; colour-blind lads are still being sent to training ships to be brought up for a profession they are physically unfit for.

That the danger is very great, is shown when an individual like myself has met with: Thirty-four colour-blind boys, who were being brought up on Training Vessels; nineteen colour-blind apprentices; sixteen colour-blind officers, and one colour-blind pilot. A total of seventy.

Fortunately the fact is at last beginning to impress itself upon the public, that there must be some very definite cause for the terrible shipping disasters occurring from time to time at night in bright clear weather, and

one great reason for my belief that bad sight and colour-blindness are potent causes of disaster, is the fact that the Board of Trade, in tabulating the causes of marine disasters, make "causes unknown" account for so large a proportion. Thus, in the Wreck Register for the year 1887, of 1,263 disasters, no fewer than 209 are placed under this heading. Do we not frequently read, in connection with these accidents from unknown causes, remarks like the following, and I now quote from "The Times" of Feb 5th, 1889: "A terrible calamity occurred in the English Channel, on Sunday night. During fine clear weather, two vessels which had had each other in other in sight for at least a couple of miles, came into collision and sank within fifteen minutes, leaving their crews struggling amid the wreckage in the sea. Of 42 men, 23 went down, and all would inevitably have perished but for the presence of a tug on the scene. This is the third collision within a few weeks, and seamen had almost begun to look upon them as periodical and ordinary occurrences, but the appalling loss of life has moved the seafaring population very deeply, and now there are some very strong comments upon their frequency. All inquiries respecting the cause of this disaster, lead to the same conclusion, that it was due to one of those astounding errors of judgment on the part of one or other of the navigators, which seem to defy all attempt at reasonable excuse. Each blames the other." But read in the light of my suggestion, we have a simple and natural explanation of a so-called "astounding error of judgment," and so long as colour-blind and defective-sighted men are tolerated in the mercantile marine, just so long may we expect to read of similar mysterious and unaccountable disasters. Take again the following, appearing in "The Times" of August 20th, 1888: "It is admitted that the vessels knew of one another's proximity for several minutes before the one dashed into the other. The weather was not at fault, the sea was not unusually

high, there was no fog at the crisis, each saw the other approaching in time to put a mile between them, and yet five minutes saw the whole tragedy played out, and 105 men and women have actually been sacrificed." Commenting upon this terrible disaster, we read: "But there ought to be some means of abolishing disasters like this of Sable Island from the list altogether. Here was neither recklessness nor calculated audacity nor lethargy. All due vigilance seems to have been exerted, and on both sides. But somebody, whether on board the "Geiser," or on the "Thingvalla," must be responsible, though, probably no penalty can ever be exacted. But the rule of the road at sea itself needs to be brought to trial, if two well-found ocean steamers in ordinary atlantic weather, with crews and officers reasonably on the look-out, can, either by its observance or its non-observance, find themselves suddenly locked in a murderous embrace. The rule ought be so simple and unmistakable as to render a collision in the circumstances of last Tuesday impossible. Controversies, of which our columns have frequently been the scene, prove that sailors, lawyers, and merchants, have not as yet been perfectly successful in devising one adequately free from ambiguities The awful end of the "Geiser" is additional testimony to their failure. The world has a right to demand of Maritime experts, rules on the subject of collisions, which only blind men, or mad men, shall be able to misunderstand or disobey." The Times, in this last sentence, most unconsciously hit on the real cause of these terrible collisions, due to so-called "unknown causes." Let me read the sentence again: "which only blind men shall be able to misunderstand or disobey." Here at last we have the truth, the whole truth, and nothing but the truth. It is not, however, necessary to invoke the aid of madmen, when we know that there are hundreds of these blind men afloat,—men who by reason of their colour-blindness, cannot tell at night time the

direction vessels are taking, and who in consequence have in the past, and will continue to send in the future, hundreds of lives to a watery grave. But neither the despairing cries of the drowning, nor the wails of the widows and orphans have had a beneficial effect upon the stony hearts of those who sit in authority at Whitehall, and after a long experience I feel certain, that nothing but a free expression of public opinion will bring them to a proper sense of their responsibilities. All present may directly or indirectly, do something to assist in the elimination of colour-blindness from our mercantile marine and therefore I venture to give you the following advice :

1—Parents should not allow a boy to go to sea, or be apprenticed to the sea, until his eyesight and his colour sight have been tested by a competent examiner. (In addition to the dangers incurred, great hardship is inflicted on the boys themselves, by their being prevented from rising in their profession, and in some cases ship-owners have raised objections to breaking the agreement, and have refused to return the premium, or any part of it, though by reason of colour-blindness or short-sight, the apprentice was absolutely unfit for the sea-life.)

2—Owners should not accept apprentices, until fitness as to sight and colour sight has been certified.

3—They should in addition to testing hands on first engagement, institute a system of periodical testing, as a man's sight or colour sight may be affected by accident or disease.

4—Men who are already sailors, and have not had attention drawn to their eyesight, should at once have it examined. Otherwise when they desire to obtain a second mate's certificate, they may find themselves rejected.

5—Sailors should avoid excessive smoking and drinking, as they tend to produce blindness, and colour-blindness.

6—Intending travellers by sea, before booking a passage should make inquiries from the Company, as to whether the seamen and officers, in their employ, have had their eyesight and colour sight tested.

It is now time to bring my remarks, with which I trust I have not greatly wearied you, to a close. The suggestion that I should read a paper before your Society gave me much pleasure, for it has enabled me to bring more closely to your notice, a subject which is not only of deep scientific interest, but of great national importance. Probably there is not an individual present whose life at one time or another, has not depended upon the correct colour vision of a railway servant, or a sailor, and there can be no shadow of doubt but that the loss of life in the past due to this simple defect has been great, a loss all the more deplorable, for being preventable. It is the prerogative of the State to protect the public in all those cases where personal forethought and carefulness are inadequate to ensure personal safety, and how a subject of such importance can have been so long and so thoroughly neglected, is a question which affords abundant food for reflection. If the State considers it a duty to prevent the sale of unwholesome or adulterated food, or to take measures against the introduction of infectious diseases, how can it divest itself of the responsibility of legislating for the prevention of marine disasters, which are sure to occur with more or less frequency if officials with defects of sight are not excluded from all those posts in which they are obviously dangerous to multitudes of people as well as to themselves. If the law tries to prevent us from catching scarlet fever in an omnibus, it should not apathetically allow us to be drowned in a preventable steamboat collision, or pulverised in a railway smash.

At the conclusion of his lecture, Mr. Bickerton stated that through the kindness of Mr. Olver, Head Master of the Truro British Schools, he had been allowed to

examine some of the boys in those schools. Out of 46 boys whom he tested, he found that three were typically colour-blind—a percentage of 6½. This was an extraordinary high percentage, but it would probably have been reduced to the normal dimensions if he had had time to examine all the boys present in the school—about 100. The result confirmed the belief that at least four per cent. of the population were afflicted with colour-blindness, and it showed how important it was that this subject should receive attention in a county like Cornwall, from whence such a large number of young men found their way into the sea-service.

Mr. Bickerton then subjected two of the boys to a series of tests, and they gave clear proof of their defective colour sight. One of them matched a skein of red wool with two skeins of brilliant green, and one of brown, whilst the others, when a red light was exhibited, described it as green.

The lecturer was accorded a hearty vote of thanks.


BLIGHT

LECTURE 11.

(Delivered on Saturday, August 12th, 1893.)

Fishing Industry [illegible] West of England.

DRIFT FISHING,

BY

BENJAMIN RIDGE, ESQ.,

(NEWLYN, W.)

Chairman :—RICHARD FOSTER, ESQ.

DRIFT FISHING.

The Lecturer said: In my former paper it will be remembered that I dealt with the Trawling fishery which has more direct interest for the fishermen of Brixham and Plymouth, where very little drift fishing is engaged in by the fishers of those ports. Trawling has to do with fish found at the bottom of the sea, such as soles, turbot, brill, lemon soles, ray, plaice, conger, gurnard, hake and skate, red mullet, and other ground fishes. The fish caught by drift nets are only mackeral, pilchards, and herrings, and those kinds are caught at or near the surface of the ocean. The trawl net has to be towed along the bottom of the ocean; the drift net, as its name implies, is thrown overboard attached to the boat by sufficiently strong rope, floated with buoys and corks, and allowed to drive along with the tide and wind, and in this way mackerel, pilchards. and herrings are caught. The common mackerel is the sort with which we are most familiar on the coast of Devon and Cornwall. It frequents the British seas at different times of the year, and constitutes a well defined family form. Of the various kinds of food-fishes caught around our coast, probably none are more interesting to the naturalist, and very few of more importance for food. Mackerel being a wandering tribe, considerable uncertainty has always been experienced in the visits to our shores, and no two seasons are ever alike. It is generally considered that the greater portion come from the Atlantic,

which probably explains why the West of England has been favoured with a larger quantity of these dainties than other parts of the British coast. As they are a surface fish they are sometimes caught by the seine net and hook and line, but by far the largest number are taken by the drift net, and this method has been known and practised by our fishermen from early times. The nets are put overboard, at sunset, and got on board again a few hours afterwards according to circumstances of the weather and fishing. This matter is worked out by experience, and can only be thoroughly learned by going fishing (to sea), which is, I suppose, the most practical school known to lovers of the piscatorial art. Cornwall has a greater length of coast line in proportion to its area than any other county of Great Britain, and it is but natural to associate with its mineral wealth (tin and copper) the riches of its seas, and to adopt for motto's sake "Fish, tin, and copper." This indeed has been its motto for many centuries, and is likely to continue so for a long time to come. It must be evident to any intelligent visitor to the county that the charm of the sea has had a strong and peculiar fascination for a considerable portion of its inhabitants, and the many fishing villages strewn along its shores, with its boats and fishing gear of various kinds, tell of an enterprising spirit, in keeping with the general character of the Cornish people. In the days of England's "wooden walls," her sons from the fishing population rendered their full share of duty to their sovereign and country; and in the mercantile marine the proudest positions have been in the hands of those whose earliest days were spent in reaping the harvest of the sea, and to-day many of the most responsible positions of this branch of our marine service are held by those whose first experiences afloat were obtained on board the Cornish fishing boats. It is not wide of the mark to say that a greater number of captains have, from time to time, come from the fishing villages in Scilly, in Mount's Bay, and at

St. Ives, than from any part of England; and the training they received in their pursuits of Neptune's hosts stood them in good stead for their future career.

But fishing as the very old men knew it, and that of to-day, is very different, though, for the matter of catching fish, very little change, if any, has taken place. But the whole round of fishing life has entirely undergone many and singular changes. The old men were very strong-minded, self-contained, firm and resolute in their manner, very decided in their views relative to their craft and calling, and not subject to change in their methods of working, so that it may be said very little alteration took place in their mode of fishing for many generations. Their intercourse with the general public was so casual that they lived almost a distinct and separate life as compared with other people, caring little or nothing for those things which lay outside their immediate occupation, and consequently were happy in a degree not easily understood by their descendants in these days. It is only reasonable to suppose that the habits and customs peculiar to the old fishermen of Mount's Bay should have had such a strong hold on them, that when any change affecting their boats and gear, and the general method of their craft and calling was suggested, they received the suggestion with doubt and suspicion. Any "new departure" was often a matter of very grave consideration with them, but as soon as any advantage was perceived in the change, then old prejudices gave way, and the new order of things became the rule. About 60 years ago the three-masted luggers saw their last days, and were replaced by the now two-masted luggers, celebrated where-ever fishing is carried on for their sailing qualities. The old men tell us that, in their boyhood, the twine for making their nets was spun by their female relatives, who also made the nets by hand. Mackerel nets were made of hemp twine, being 75 yards long and 110 meshes deep (of 21 meshes to the yard), and weighing 45 lbs. per net. By

the application of machinery for net making, the home-made article soon became a novelty, and to-day but very few indeed are made by the nimble fingers of our Cornish fisher lasses.

Bridport became greatly interested in this industry, and soon many large net-making machines were in full swing, producing in large numbers these fatal snares for Neptune's hosts. Hemp twine had in turn, to give way to cotton for this purpose, owing to the latter being cheaper and a more effectual snare than the ordinary twine net. As innovations to long and deep-rooted practices began to take effect, a corresponding amount of competition took hold of the sons of those old worthies, and as the need for new boats became evident, the desire to increase their size also manifested itself, and though the old men were constantly protesting against such ideas, the adventurous spirits of the juniors prevailed, and the demand for a larger class boat became the fashion. From the 24 feet keel to the 32, and then from the 34 to the 40 feet keel, was only a matter of time, and with this, also, the open boat of former years was given up for the decked boat of more recent date, and now this class of boat has to give way to those of 45, 50, and even 54 feet keel, with corresponding improvements in the general working. To mention one important point, the cog-wheel capstan for hauling the nets is seriously threatened by the use of the steam capstan, which in a short time must become as popular in this part of the country as it is among the fishers of the North. The increase in the number and size of Cornish mackerel boats has also been accompanied by a very large addition to the number of nets per boat, viz: from 21 to 50, and even 80 nets per boat; which shows a large increase in the total amount invested in this important fishery. To go back to the time when the very few of the oldest of the Mount's Bay fishermen were in the hey-day of their calling (they are now enjoying a well-deserved leisure), the mackerel fishery was

prosecuted under circumstances peculiar to that period; and fortunately, too, are altogether a thing of the past. The typical boat was as unique as were the fishermen themselves. In rig, size, and shape, the boats were the very facsimile of those used by the Brittany fishermen of to-day, viz: three-mast luggers, about 34 feet keel, and not decked, with round stern, and possessing sailing qualities superior to any other kind of fishing boat of its size; and many are the interesting and exciting tales of the exploits those famous boats have performed, when caught in the offing off the Lizard, or off Scilly, or the Land's End, at the mercy of a north-west gale, with the seas running mast-head high. It would always be with considerable glee, too, that some of the more daring of those old salts would recount an occasional chase by a Government Revenue Cutter (for were not those the days of running the gauntlet), and how, if it was a turning to windward, the Revenue Cutter was sure to get the worst of the chase, such were the sailing qualities of those celebrated Cornish fishing luggers. The mackerel fishing was not then so extensively carried on as at present; the boats were comparatively small, and the number of nets did not exceed twenty, and were made of flax. It was seldom that the old men went very far off shore, and whilst mackerel were as plentiful then as now, yet there were not such quantities landed as in these days. The facilities for selling these dainties were very limited, and conveying them to inland towns to a distance was a matter of considerable difficulty and expense. Frequently boats would proceed direct from the fishing ground to some of the following ports, viz: Plymouth, Weymouth, Southampton, and Portsmouth, in the English Channel; and to Bristol, Cardiff, and Swansea, in the Bristol Channel, whilst the greater portion would be sold throughout the two counties of Devon and Cornwall, a remnant finding their way to towns at a distance, such as Bath, Bristol, London, and Birmingham, by coach. Thus the mackerel

fishing was prosecuted by Cornish fishermen under conditions quite in keeping with the times gone by, which to us in these days of railway facilities seem almost incredible. But the introduction of the railway to our shores has effaced the old order of things, and revolutionised the whole system of fishing. The old system has given way to the new.

The development of the railway system to the West of England gave considerable impetus to the fishery, and during the first few years of the railway to Plymouth considerable enterprise was put forth to take advantage of the altered state of things, and the principal fish merchants of those days engaged fast-sailing cutters, principally trawling smacks—notably among them the "Baron," of Plymouth—to run with mackerel from Newlyn and St. Ives to ports in the Bristol Channel, and also to Plymouth Very often, too, these cutters would meet the boats on the fishing grounds, where the merchants would purchase the night catches, and proceed direct to the above ports. For many years this was the *modus operandi* for getting the fish to the principal markets, and as the trawling fishery in the North of England was then only in its infancy, the Cornish mackerel fishery was of great importance, and during the Lent season the prices obtained for these fish ruled very high, and the fish were as eagerly sought after as soles and the other kinds of prime fish in our own principal towns, as well as those of France. In those days, however, the duty on fish imported into France from England was prohibitive, and frequently French Fishing boats would come across to Plymouth and buy mackerel to carry to their own country under the pretence of having caught them off the British coast, and considerable trade was done in this way. But this is no longer the case; nor has it been for many years past. Fifteen shillings per cwt. was the duty then levied on imported fish from Fngland, and it practically shut out our own English merchants, and threw this part of

our trade into the hands of the French fishermen, as already stated. But since the reduction in the duty to 2s. per cwt., and the facilities offered by the railway system by through rates to all the principal towns of France, and even to towns in Belgium; the trade in this particular has grown considerably, not only in mackerel but in all kinds of prime fish—as well as in rays and conger. This was seen in the increase in the number of boats engaged in line fishing, both in Cornwall and at Plymouth. A few years ago, however, the old tariff of 15s. per cwt. was enforced, and which now prevails and has considerably injured this part of our fishery.

The spanning of the river Tamar by Brunel's bridge at Saltash, had a decided effect on the Cornish fishery especially in Mount's Bay and at St. Ives, and from that time to the present the most marked increase and improvements have being going on. The advantages which the fishing industry obtained by the completion to Penzance of the railway, soon put an end to the method of taking the fish on to Plymouth and other ports by the sailing cutters, though for a few seasons the merchants persevered in their old ways, but eventually had to settle down to the fact that the "iron horse" was more convenient than the sailing cutter. The principal personages who were associated with these events have since gone over to the majority, but they lived long enough to realise the mighty changes that took place as the railway was extended to the Western shores. Their descendants readily adapted themselves to the altered circumstances of the trade, as well as the requirements of the times, in the same persevering spirit so characteristic of their predecessors.

The mackerel fishing invariably may be said to begin in the latter part of February, a few miles off Plymouth and the Lizard. This is known as the spring fishing; the fish are not very large during this part of the season, and by the end of March, and sometimes in the beginning of

April, they leave the coast for other seas. The fishing then goes on farther from land, and also off Scilly, and often the fishermen have to go from fifty to a hundred miles N.N.W. of the Land's End to find these dainties, which in point of size, are far superior to those caught off the Lizard. The St. Ives boats prosecute their operations in the North Channel, and often join those of Mount's Bay in carrying their hazardous operations far into the Atlantic. It sometimes happens that they are overtaken by very strong north-west gales, and meet with serious loss of gear, as well as loss of life. The difficulty the old men had to encounter during the summer months in bringing their harvest to land in a fresh condition is now overcome by the use of ice, which they take on board with them in large quantities, and for this the large boats are especially adapted, being fitted up for the purpose. To meet the demands created for effectually working this part of the the trade, a company was formed for making ice, whose works are established at Gulval, near Penzance, the ice being stored at Newlyn. Large quantities are yearly imported by several ice merchants. Without the advantages thus secured, mackeral fishing during the summer months could not be carried on so successfully as it has been for many years past.

The cost of keeping a fleet of nets in a thoroughly good condition is considerable. But besides the wear and tear by ordinary risks, it often happens that the loss the mackerel fishery sustains, through damage wrought by passing vessels to nets, is such that the savings of years of hard work are destroyed in a single night, and that, too, without the least possible chance of obtaining one shilling by way of compensation. When the fishing is being prosecuted near Start Point, the Lizard, or the Land's End, or in the track of coasting vessels from the Land's End to the Start, according to the time of the fishing season, scarcely a night passes but some or other of our mackerel

fishermen have to report serious losses to nets. In fishing for mackerel the nets are so arranged that they shall float level with the surface of the sea, and vessels passing over these nets are sure to do considerable damage, especially if they be steamships, for it often happens that the propellor becomes entangled in the net and ropes, and there is nothing for it but wholesale destruction. It is generally during the spring fishing off the Lizard that this state of things becomes the most serious, and during one night last year damage was done to the fleet to the extent of several hundred pounds by passing vessels sailing over the nets, which could have been avoided, as every boat exhibits two bright lights when riding at her nets. The spirit of "nothing venture nothing have" very often can be carried too far, even in fishing, and sometimes our fishermen are tempted to shoot their nets in accordance with these promptings, when, to their sorrow, instead of getting a good haul of fine mackerel, they have to pull on board the remains of their nets, all in rags, which means no profit and plenty of work in repairing the torn gear. To successfully work the mackerel fishery now-a-days requires two fleets of nets, as the fish caught off the Lizard during the spring season are considerably smaller than those caught off Scilly and away into the Atlantic during the months of May, June, and July; hence the meshes of the spring nets are smaller than those required for the summer fish. Thus it is that two sets of nets are required. This was not the case in former years, as the old fishermen used one set of nets for the entire fishing, probably owing to the fact that they did not go so far from shore during the latter part of the season, and there was not the necessity for using so large a mesh net as now. This custom also entails an additional outlay for gear, and taking into consideration the cost of tanning the nets in order to preserve them, it will be seen that this macherel fishery is exceedingly expensive, and requires the utmost care in maintaining the craft in an efficient con-

dition, as if not carefully looked after a whole fleet of nets would soon become rotten and useless. Several times during the season it is necessary to get all the nets on shore and dry them, and any neglect in this direction soon shows itself. In the method of tanning nets very little alteration has taken place, cutch being generally used as the principal ingredient for this purpose, and if this is not thoroughly well done when the net is new, it is almost useless to attempt to preserve it afterwards, as past experience has conclusively shown. In the matter of building these luggers, it has never been necessary to go out of the county of Cornwall for a first-class boat ; in fact, it can be truly said that this kind of boat building has become quite a speciality among the builders of Porthleven, Mousehole, Newlyn, Penzance, and St. Ives, and the success which the several builders have obtained in their profession have secured them many orders for luggers at Lowestoft and other ports, where they have given the utmost satisfaction.

From the earliest times the principle which has been in force in working this fishery has been that of mutual co-operation, doubtless from the fact that the boats and gear were usually the belongings of those whose families were, as a whole, interested in the concern. It often happened that the crew were members of one family, and there was therefore, a common interest in its success or otherwise. The principle of mutual interest still survives, though in a somewhat modified form ; the relative positions of capital and labour are more closely connected than is the case with any other part of the English fisheries. The boat is almost invariably the property of one person, whilst the nets belong to the owner of the boat and the crew, each member having his proportional number of nets, which thus insures him a full share in the earnings. One strong feature in connection with the development this fishery has undergone is that it has been purely the results of private enterprise,

and whilst Government grants have from time to time gone across the Irish Channel for the development of the fisheries there, the Cornishmen have had to depend on their own resources, and to make the best of these as times and circumstances would permit. In the matter, also, of harbours for the protection of their boats, the experiences of our fishermen have been those of considerable difficulty, and the difficulties have been faced and met with a determination deserving more help than it has ever been their good fortune to receive from the powers that be. If the least encouragement had been given to the extension and improvement of the fishing harbours of Cornwall—at Polperro, Mevagissey, Newlyn, and St. Ives—some twenty years ago by the Government of the day, the fishing industry would be double what it is to-day, for at these ports the boats have increased in number far beyond the accommodation which these harbours now possess. And it is with no little satisfaction that those interested have observed the very practical way in which the Newlyn folks have led the van in beginning harbour works which, when completed, will be a credit and an honour to the fishing population of that village, as well as a monument of persistent energy on the part of the Newlyn Commissioners, who are interested in this important undertaking.

During the late International Fisheries Exhibition, the Prince of Wales read a Paper written by his brother, the Duke of Edinburgh, in which he paid a well deserved compliment to the admirable sea-going qualities of the Cornish lugger fishing boat, from his own personal observation when he had command of the Channel Fleet a few years ago. His Royal Highness said he had often seen these boats in all kinds of weather battling successfully with the gales and heavy seas, at times when many large merchant ships were making very bad weather of it, and appearing to be in great distress. The writer can thoroughly endorse the estimate His Royal Highness placed upon the

qualities of the Cornish luggers, and knows of no class of fishing boat of its size that surpasses these luggers for speed and stability combined. The following case will doubtless be read with interest, as showing what these luggers are calculated to do. In the year 1854, no little excitement was created amongst the fishers of Mount's Bay, when a party of Newlyn fishermen decided to go to Australia in one of the luggers of that day. The Mystery, of Newlyn, of 36 feet keel (an open boat) was decked and fitted out for the voyage, and the crew were Richard Nicholls (Captain), Job Kelynack, Richard Badcock, William Badcock, Charles Boase, Philip Curnow, of Newlyn, and a Penzance man named Lewis, who was shipped as cook and steward. They left Gwavas Lake, Newlyn, on Saturday, November 18th, 1854. The whole of the fishing population of the locality turned out to wish them farewell and God speed. The scene at their departure was intensely exciting, and many a stout-hearted fisherman was wrought upon at the sight of so daring an enterprise, in a craft not more than thirteen tons register, and many were greatly concerned for their safe arrival at their port of destination—Melbourne, Australia. The first day's sail, according to the ship's journal, was very pleasant, and several days were passed with very fine weather and pleasant breezes, and then it became showery with fresh winds and squally. On the 25th of November, at noon, they made the island of Madeira, bearing south-west by south. The next day in lat. 31·1, N. and long. 18·6 W. they spoke to the brig 'St. Vincent,' from Liverpool to the Cape of Good Hope, out sixteen days, and an hour later they exchanged colours with an English barque. From this date to Dec. 3rd, they experienced a series of strong winds, heavy seas, and again light breezes, when, at noon of this day, they sighted the island of St. Antonio. On the 23rd of Dec., with a strong southerly gale blowing and a heavy sea running and under reefed small sails, the island of Trinidad was sighted; and on

the 17th of January following, they rounded the Cape of Good Hope at seven in the evening, and hove to in Simon's Bay until daylight. On the following morning they let go their anchor close to the dockyard, and during the day hundreds of visitors came on board. Here they hauled their noble little craft on the beach, examined and cleaned the zinc sheathing on the bottom, and took in a fresh supply of water. On the following Sunday (Jan. 21st) the whole of the crew attended Divine service on board Her Majesty's guardship, where they were well received by all hands. Next morning they left for Table Bay to take on board Her Majesty's mails for Melbourne, and on leaving they were heartily cheered by the crews of all the ships in port. At two o'clock on the morning of the 23rd of January, they arrived at Table Bay, and as soon as the anchor was dropped a great number of visitors came on board anxious to see those brave Cornish fishermen who had dared to come on such a voyoge, in so small a craft. On the following day the mail was put on board the renowned little 'Mystery,' of Newlyn, in the charge of Cornish fishermen, who thoroughly understood what their duty was, and never was Her Majesty's mails in safer hands than these, the crew feeling as proud to be trusted with the bags of letters as were the officials confident that in placing them on board her, all was well. When it was known that this noble little craft was to take the mails to Melbourne the excitement was intense, and as she left the anchorage, the cheers were loud and long from the shore, and were echoed and re-echoed from every ship in the bay, including a Dutch frigate. This pleasant incident is still kept fresh among the many remarkable episodes of that district. During the voyage up to February 22nd, nothing had happened to seriously imperil the safety of the 'Mystery' and her crew, though they often met with strong winds and high seas, which thoroughly tested the sea-going qualities of this remarkable fishing lugger. But before she was to reach Melbourne

Old Father Neptune had purposed to put the crew to their wit's ends, and to test the 'Mystery' to her utmost. On the 23rd of February, according to the journal, a strong gale from the north-west with very heavy seas and rain overtook them, and they soon had their craft under very small canvas. The gale increased until it blew a perfect hurricane, the sea ran mountains high, and the rain fell in torrents, and it being no longer prudent to run in such weather they brought the boat's head to the wind, and drifted to a raft which they prepared for the purpose, when she rode very easily, and shipped but little water. During the night the wind veered to the westward and moderated, and then the crew hauled the raft on board and set sail again, though the wind continued to blow very hard, so much so that they were obliged to let her run under bare poles, the wind being very squally, with heavy snow showers. The weather improved but little for the next four days, and on the 5th of March they had to face another hurricane, which compelled them once more to ride to the raft, it being impossible to keep sail on this little craft of thirteen tons. During the night the hurricane continued with terrific force, and next day (the 6th) was the heaviest weather they had experienced since leaving England, yet this gallant little fishing boat rode the mountain of seas remarkably well and came out of the ordeal without serious damage. At nine o'clock in the evening the weather improved, the raft was hauled on board, and sails set for their destination. The next two days was pleasant sailing, but on the 9th the raft had to be used again. After this, however, better weather was experienced, and at eight o'clock on the evening of the 14th of March, 1855, the 'Mystery,' of Newlyn, with Her Majesty's mails on board, dropped anchor off William's Town, and handed the mails over to the authorities, who were as proud to receive them from the crew of the 'Mystery' as if they had been brought by a captain of some clipper merchant ship, and Captain Nicholls and his plucky

comrades felt equally honoured that such a duty had been conferred on them. They met with a reception worthy of the occasion from those on shore, and the story of the Newlyn fishing lugger 'Mystery' and her successful voyage from Mount's Bay to Melbourne, will not soon be forgotten in that land.

Beside the boats of Cornwall engaged in this important fishery, a very large fleet come yearly to fish in company with our fishermen from Great Yarmouth, Lowestoft, Shoreham, Brighton, Hastings, Newhaven, which together make up one of the finest fleets of drift net fishing boats around the coast of England. The rig of those hailing from Great Yarmouth and Lowestoft differ generally from Cornish craft, being dandy rig and somewhat larger, and generally carry more nets and have a crew of nine hands, whereas our boats are manned with from five to seven hands including the cabin boy. It is worthy of note that during the past few years a considerable increase has taken place in the number of boats from Gt. Yarmouth and Lowestoft which frequent this coast for the mackerel fishing, and, one can scarcely imagine a more picturesque sight than when some 300 or 400 of these noble fishing craft of various size and different rig, are leaving our shores to go to the fishing grounds on a breezy morning, each crew doing their level best to get on to the fishing grounds in good time to secure a suitable berth for the night's fishing; returning again the following morning with greater speed if possible, to secure an early market for the sale of their night's catch. Here a scene of considerable activity is daily witnessed as crews bring their fish on shore either in punts, or land them at the Quay, where salesmen and buyers are always waiting to sell and purchase, the sale being by public auction.

In regard to Tythe, tythe taking of fish has been practised from very early times, and often created no little trouble to boat-owners and fishermen. It became very

unpopular in some places, the collection especially being attended with much difficulty, and at least in some cases it was voluntarily surrendered. In 1831 the Collector for Mousehole went there fully armed with pistols. It had been snowing very heavily just before he arrived, and the fishermen seized and threw his pistols over the cliff, made use of nature's powder and shot, pelted him with snowballs out of the village and chased him to Newlyn, where he received a similar treatment. I may say to commemorate their victory the fishermen placed a board against the end of a house at the top of the cliff at Newlyn, on which the words are painted "No Tithe One and All, 1831," and from that time to the present the unfortunate Collector has not thought it worth while to return, and so no fish tythe has since been collected either at Mousehole or Newlyn. A very playful, though effectual way of boycotting. At St. Ives many disputes have taken place with regard to fish tythe, and in 1837 Mr. T. S. Bolitho took the chair at a meeting, when the following rates for the tythe were agreed to, and accepted on behalf of the Wellesley property. If pilchards sell for 30/- per Hgd. to pay 6d. per Hgd. tythe; 30/- to 35/- 9d. per Hgd.; if 35/- to 40/- 1/- per Hgd.; and for every 5/- above 40/- 3d. per Hgd. to be added. The seiners and drift men to pay no tythes, but since then, about 12 years ago, the tythe was bought by the seine owners for £1,200 off Lord Cowley's Trustees, through the intervention of the same gentleman, Mr. T. S. Bolitho.

I might refer to the very singular practice which prevails in connection with the port of Plymouth, viz: the Mayor's dues, which is taking so many mackerel or pilchards, or any other kind, by one of the officials of the Corporation from fishermen as soon as the boats arrive at the Quay. The redeeming feature, however, of this custom is that the fish so collected are distributed after the Mayor has seen them, to the poor of the town by his worship's request. I have not been able to find out how this custom was established.

What is of first consideration now is to encourage this vast industry, for further development, and this can be done very materially by getting wholesome fish to the doors of the teeming masses of the population.

Distribution, of course, comes in here, and about this matter and railway facilities with cheap rates for transit, is the ever green question to pull us over the tide, as a fisherman would say. So much has been said of late about this matter though so little done, that I must forbear saying anything about this vexed question.

One must hope that the results of the present exhibition, among many others, may so bring home to all concerned the necessity of taking advantage of every opportunity to foster at least a real interest in the fishing industry of the country, and to help any endeavour to promote it in any way possible.

The pilchard fishery of the country is still of great importance, and though the seine fishing has of late years been somewhat a failure compared to what it was years ago, yet the drift pilchard fishery continues to hold its own, and promises to be equal this year to former years. As so much has been said lately concerning the habits and haunts of these fish, I will only add that working over some figures of quite recent dates, and not forgetting that the method of curing those wiley creatures for exportation has undergone a complete change from the old dry salt method to curing by pickle, the results of the past seven years are not so disappointing as was first supposed when the old method had to be abandoned.

On the motion of Mr. Richard Foster, a hearty vote of thanks was passed to the lecturer, and a similar compliment was also paid the Chairman.


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LECTURE 12.

(Delivered on Tuesday, August 15th, 1893.)

THE ENEMIES OF OYSTERS.

BY

J. M. R. PHILPOTS, Esq., J.P.

Chairman :—J. D. Enys, Esq.

ON THE ENEMIES OF OYSTERS.

Lest anyone should imagine that the cultivation of oysters is an affair of small importance, and scarcely to be ranked even with the cultivation of gentles for bait, I propose to shew, both by figures and facts, how vast are the interests involved in ostra-culture; and that whether we regard the industry from the pecuniary or the social or the political or the economic stand-point, it is worthy of the attention of any government, and of a scientific association like the one which I now have the honour of addressing. My first statistics are from the report of M. George Michel, and refer to France. He says that in one year the total output was more than fourteen hundred million oysters, which provided labour for about 300,000 persons, and was worth £530,000 in money to France. And this rich harvest was reaped from about 50 square miles of the sea-bottom, which would otherwise have remained entirely unproductive, and must therefore be accounted an acquisation of valuable territory of far more use to France than many times its area of African forest or Siamese swamp.

And now take an individual example of how this great total has been achieved. About 24 years ago an observant Frenchman of the Isle of Ré noticed that the chief secret of successful ostra-culture is to provide a solid perch for the young and free swimming oyster to rest upon within 48 hours of its birth. Being a stone-mason by trade he enclosed a small area of the foreshore with a rough stone dyke, into which he brought a few growing oysters, and scattered about some large rough stones on which the young

oyster-fry might find a rest. The venture answered admirably and began to pay at once. And at the present time there are 4,000 oyster-parcs in the Isle of Ré, yielding an annual revenue of £100,000.

Passing for a moment from France to the United States, we are told that in Maryland alone the industry maintains 10,000 men, and employs 600 boats, and though the statistics for the whole Union are not yet completed, it is known that the enormous oyster-trade of the United States is one of the wonders of the world.

From almost every sea-board in temperate or tropical regions there comes the same testimony; testimony that oyster-breeding, though disastrous when managed ignorantly, is, when conducted in accordance with molluscan habits and needs, one of the most productive and expansive industries at present open to mankind. And now let us look at our own land. A glance at the map shews an indented and winding coast-line furnishing bays and estuaries, such as oysters love, the like of which is not to be seen in any land. It is evident moreover from the trade reports that the voracity of Britons in the matter of oysters, fully comes up to their acknowledged eminence in all other departments of civilized life. The annual consumption of oysters in London is about 500 millions, weighing something like 50,000 tons, which at an average cost of two shillings a dozen, represents more than four millions of pounds. Taking the whole kingdom, we are said to get through about 3,000 million, representing at the same average price, no less than 20 million pounds.

But does this infinitude of oysters all come from our own most convenient shores? and does the industry maintain a teeming fringe of busy population all along that winding coast? no indeed. The answer is given in such paragraphs as that which tells us how in May of this year, there was received from France for the Whitstable waters, the largest consignment of foreign oysters ever laid in the Company's beds. In two hours and a half over 3½ millions of "French

Imperials" were discharged from a steamer specially built for this branch of foreign trade. As a matter of fact the home-consumption of about 3,000 million oysters is all drawn from foreign sources, except the comparatively small proportion of 40 to 50 millions. We have said enough to convince us that the science of ostra-culture involves pecuniary, industrial, and other interests of such magnitude as to warrant all the care and trouble which a society, or a government can bestow.

I have next to justify my selection of the *enemies* of oysters, rather than the oysters themselves, as the subject of our present consideration. And this I can do by shewing that the oyster, if merely protected from its foes, if provided with a fair field and a little favour, may be safely left to do all the rest of the business for itself. Such is its amazing fecundity that were it not for its legions of enemies, a solid rampart of oyster-shells would soon be encircling all our coasts, and filling up our harbours, estuaries, and bays. An oyster is said by Poli, a great authority on this subject, to contain as many as 1,200,000 eggs, so that from a single oyster enough to fill 12,000 barrels might be born. Multiply this by the number of adult oysters in all the oyster-beds, and imagine what a total would appear. And it should be noted that in computing the increase we must take the full number of adult oysters, not the number of adult *pairs*; for each oyster is a pair in itself, being at one time male, and at another time female, so that every single individual is competent to do the ovulation and fecundation, and perform the whole work of reproduction by its sole unaided self. Moreover these ova, or "spat" as they are technically called, are produced as a kind of fluid cloud, numbering about 2,000,000 individuals to the cubic inch, an arrangement which greatly facilitates their dispersion and distribution far and wide throughout all seas. How then, does it come to pass that the whole ocean has not long ago been converted into one solid oyster bed? I reply, that the fact is due to the existence

of those legions of enemies of which I am now treating. So many and so active are those countless foes that it is computed that not more than one in every million "spat" ever arrives at maturity. Now I hold that if we can help the oyster ever so little, and so shift the balance of life that these unfortunate molluscs shall have a somewhat better chance in the struggle for existence, we shall soon see a vast result. Of course, we must not dream of preserving to every oyster even a tenth part of its 1,200,000 progeny; but I maintain that if we can effect a saving which is only very slight *proportionately*, the increase in actual numbers will soon be simply incalculable.

In counting up the enemies of the oysters, the first thing that strikes us is that every separate locality has its own special pest. Thus, in the Channel Islands the enemies which give most trouble are the Octopus, the sea-urchin or echinus, and man. On the French coasts the chief foes are sting-rays, skates, sand, and man. In Pool harbour we have to contend against mud and man. In the Connecticut beds of Long Island Sound it is sand and man. In the estuary of the Thames it is star-fish, whelk-tingles, which were so prevalent at one time in Blackwater, that fishermen were paid 6d. per hundred for bringing them on shore; lobsters, crabs, and, of course, man. Even in Falmouth Harbour, I see that in addition to star-fish, dog-whelks, "coral" and mud, the committee enumerated "over dredging," which is only another way of saying the improvidence, or the cupidity, or perhaps even the stupidity, of the arch-enemy man. Indirectly, I suppose too, that man must be responsible for the mischief done by mine-water. Huge volumes of water contaminated with iron, copper, lead, or tin, discharged by rivers into the blue sea must do great mischief to the fisheries of the Cornish seas, which (bathed as they are with the tepid waters of the great Atlantic current) ought to teem with life of every kind. But I know full well that its mining interest is dearer to Cornwall than even its fishing interest. And, between these two conflicting interests, the wisdom of

Cornishmen must be permitted to decide. In many other localities there are many other pests, such as sewage pollution, heat, cold, too much salt, too little salt, gulls, cormorants, "spat" eaten as food by all other fish, mussels, shrimps, cliona fungoid growths, great guns, and carbonetted hydrogen (which emanates from mud); but as man is the worst of all, then I will point out wherein man must mend his ways; and I will proceed to say something in detail about the other enemies of oysters.

In the first place it is imperative that whatever close time is required shall be honourably and conscientiously observed. With different breeds, and in different localities, the close months may vary considerably; but whatever they may be they ought to be respected. Yet there are found men—impelled, we must suppose, by a mixture of improvidence, greed, recklessness, and wilfulness,—who persist in evading regulations and restrictions with a perseverance and ingenuity worthy of a better cause. The well-known rule for the English close-time has been embodied in a Latin epigram; "Mensibus *erratis* vos ostrea manducatis;" where "erratis" has nothing to do with erratic, but means "which have an R in them." And of the many clever devices for evading the rule of R, the most ingenious was that of the man who was had up for selling oysters in the month of August. He contended that August *is* an open month, "for does'nt O.R.G.U.S.T. spell Orgust? and is'nt there an R in it? And 'tis a pity that great gentlemen have to come to a poor oyster-dredger to learn how to spell." More difficult to deal with, even than these, are the thieves, robbers, and pirates, who persist in poaching on all rich and well-stocked oyster-beds. The worry and expense which they cause detracts seriously from the profits of the industry. At the Cancale parcs the defence is arranged in four departments, and is almost suggestive of a state of siege, and a standing army. In the French Report of Bouchon-Brandely, the service of guard is thus enumerated: (page 15).

1. The usual police supervision.
2. Seven special guards.
3. Two general guards; and
4. Four sworn guards.

Again does the French Report (page 19) refer to these human nuisances,—it says, "This, (the coast-line at Brest), is broken by numerous creeks in which the marauders, signalled by their confederates who are on the watch, find refuge from the pursuit of the fishing guard. Being provided with boats of very light draught, and possessing a perfect knowledge of all the creeks and coves, they quickly take refuge where the government vessels cannot follow them." But measures of coercian have proved ineffectual; so too has remonstrance, and the marauders will not see that their present conduct is destroying the harvests of the future, let their motto be Policy is the best honesty. The facilities offered by railways for the quick removal and sale of their booty, causes the robbers to turn a deaf ear to all remonstrance. This throws a curious light on the passage in the Official Maritime Returns for 1891 (I.) which ascribes the exhaustion of French oyster-beds to the multiplication of railways. In this connection may be cited the allusion of Mr. Brooks to the happy oyster-grounds of Maryland (page 202), where, by the introduction of fresh springs, the sea can be made just too fresh to please the star-fish, but exactly right to suit the oysters; and where there is no ice, no storms, no tides to hurt, but only "robbers," or rather "*takers*," a courtly paraphrase preferred in Maryland, because all property is held to belong to the State and not to individuals, wherefore, by an amiable but curious logic, when individuals appropriate state-property, they term it "taking," but not "robbery." In pursuing our catalogue of enemies, we may find much help in the list given by Bouchon-Brandely. First he enumerates sedimentary deposits, either sea-sand by which the oysters are smothered, or fetid mud (p. 9), by which they are poisoned. A sand-storm on the sea-bed does very great

mischief. A very little of it within the shell seems as irritating to an oyster as it would be to a human larynx; and in large quantities it buries the molluscs alive. But mud, even Thames mud, is said to be only injurious in large quantities; indeed we are gravely told that the fattening properties of the Thames estuary are due to the nourishing qualities of the London sewage held in suspension, to which also the aristocratic whitebait owes its excellence, for it refuses to flourish anywhere but in the filthy waters below Greenwich. Far more serious than a little sewage, are parasitic growths which prevent the valves from opening; and also confervæ and all kinds of marine algæ, which either foul the water by thickening it, or bury the bivalves in a dense jungle of marine vegetation. Added to these must be overcrowding, as when fifty thousand oysters are stored in a parc which is calculated for only one thousand. The cure suggested for all this class of foes is periodic cleansing of the beds; shifting the oysters whenever required; and occasionally letting the submarine fields lie fallow for a season ("Mettre en chômage" is the phrase for this fallowing of the water-fields.)

Another class of hostile influences includes strong tides, storms, breakers and violent winds, which cause violent currents. The injury in this case is done chiefly to the spat, either by crushing it or by carrying it far away. Protection is afforded in many ways; two may be mentioned here, first by surrounding the beds with a double row of palisades and hedges of basket-work to check the violence of the sea; and secondly by giving the spat a plenty of objects to perch upon, so that, when anchored, they may be less at the mercy of the mud and waves. These perches are called "collectors," and are of all kinds, from logs, stakes, slabs of schist, fascines, fagots, and similar simple devices, right up to the ingenious V-shaped tile, very hard in itself, but coated with a softer lime-wash which allows the adherent oysters to be detached without trouble or injury to tile or hand or shell.

For another group of enemies I will combine the observations of Bouchon-Brandely (p. 45), and Professor Möbius (p. 14), who speak of them as either defect or excess in the saltness, the freshness, the temperature, and the movement of the water; to which may be added a deficiency of lime. With regard to the movement of the water,—a heavy surge near by does good by aerating the water, but the surge must not pound directly on the oyster-bed. Currents may be beneficial by bringing fresh food and water; but if at all too strong they bury the oysters and sweep the spat away. Too great salinity of the water arrests the production of spat. American oysters have never been known to spat in this country or in France; and the assigned reason is the greater saltness of the European seas. A deficiency of salt causes the oysters to become dropsical and insipid, or positively disagreeable. It is found, however, that the introduction of a fresh-water stream is beneficial in many ways, as by preventing enclosed sea-water from becoming too salt by evaporation, or too hot from exposure to the sun; we must repeat, too, the assertion of Brooks (p. 202) that salt water can be made just too fresh for star-fish to live in, but exactly salt enough to suit the oyster's constitution; and thus the latter is freed from one of its worst foes by the simple cure of cool fresh water. The water must be *pure*, and free from the wash of land-floods and injurious metallic ingredients.

In proof that a little pure fresh water may do the oysters good, some curious experience at one of the Gironde oyster-bays may be here cited. The proprietors took the greatest care to keep a small fresh-water spring from discharging into the sea lest it should hurt the oysters. For three years emaciation was the rule in the beds, and reproduction was at a standstill. At length the beds were abandoned, and soon the fresh waters of the brook again found their way to the sea. Some time afterwards an accident turned up some remarkable fine oysters; and further search revealed healthy spat, especially in the vicinity of the spring of fresh water.

The proprietors took the hint, and before long they had the satisfaction of seeing their collectors loaded with spat, and everything going on prosperously. The virtue of the land-spring was that it kept down the marine temperature and salinity. Extremes of temperature are among the deadliest enemies of the oyster; and the remedies are sometimes ingenious, but not always easy. In one case when an oyster-basin became frozen over, the chilled water was immediately let out, and a warmer supply drawn in from the sea, and the ice-sheet was covered with straw and hay. The loss was only about 100 oysters. At Hayling Island a steam engine is employed to keep the water thawed, and fires of coal and coke are kept burning at the water's edge. Too much heat, as when the sun pours its rays into shallow waters, is quite as fatal as too much cold. It is said that a moderate growth of zostëra marina, or sea-grass,—a flowering plant which grows freely in Poole harbour, and the waters of estuaries—forms an agreeable and efficient shelter. The question of temperature is involved in the still larger question of acclimatisation. It has been remarked that foreign oysters, like foreign toys, ought to be legibly labelled with the name of the country from which they come. For it is found that oysters "made in Germany," or in Holland, or in France, or elsewhere, refuse to "spat," though they quickly get fat in British waters. Whether this be due to the change of temperature, or to all the many complex conditions implied in the term acclimatisation, is not yet discovered. Still the fact is clear that though millions, and perhaps billions, of foreign oysters are imported and laid down in English beds, we must not depend on them for maintaining our own future supply, because, though they manage to live and grow fat, they fail to accomplish the work of reproduction. Yet change in itself is not necessarily injurious to the oyster. Thus, a degree of mud which is fatal to spat seems not unsuitable for the feeding stage. And the semi-stagnant sea-water which is at one time undesirable,

becomes exactly the right thing when the greening and fattening have to be accomplished. Hence, if an oyster commences life on a rocky bed, and is thence transferred to a muddy creek, and is finally passed on to the stagnant greening basin, it is quite possible that the changes may be in all cases beneficial.

Resuming our almost interminable list of foes, I come now to the sting-ray, a fish which is destitute of teeth, but both jaws are hard bone, with which they have no difficulty in grinding up an oyster-shell. To guard against them a fence of scantling is erected around the beds, driven four feet into the mud, and furnished with loose portions which swing about in the tide. Not the least of the enemies of the oyster is Asteria, the star-fish, five-finger, or devil-fish. It is an accomplished ansesthetist; it scorns an oyster-knife, but pours out of its mouth a paralysing fluid under which the adductions relax, the valves open, and with no further trouble the star-fish proceeds to dine.

Crabs are said to have a way of inserting their larger claw as a wedge between the valves of an open oyster, and using the lesser claw as a forceps, they pull the victim out. Personally I would think that more are devoured when the oysters are young. Purpura lapillus, the dog-whelk, bores through a shell with its tongue, and sucks out the mollusc. The only proposed remedy where the beds cannot be cleaned, is to scrape the whelk-eggs off the rocks at low water.

Curious tales are told of monkeys, dogs, foxes, and birds, which have attacked oysters, and not in all cases successfully. Among the birds we must especially name Hæmátopus ostrálegus, otherwise called the oyster-catcher, of which Mr. Mansell-Pleydel, in his "Birds of Dorset," writes thus at the 84th page; "The oyster-catcher is frequently seen in the Autumn, and at that season is generally distributed along the coast. A few pairs breed on the sandy portions of the Poole estuary, Weymouth, Worbarrow, and Studland. Should any approach be made

towards the nest or newly hatched young, the parents with plaintive cries fly round and round overhead and endeavour to distract attention, very much as the peewit does under similar circumstances." We may gather from this, that Hæmâtopus has no objection to our southern coasts, and if ever oysters become very plentiful, this oyster-catcher will have to be reckoned with. The oyster has a hard battle to fight against the combined attack of a marine worm which drills the shell with the flinty teeth which cover its ribbon-shaped tongue, and the sponge cliona which avails itself of the aperture made by the worm to get inside and riddle the substance of the shell.

I must pass over the rest of the legion of enemies which molest the oyster, and I will conclude, drawing your attention to a question which I think is comparatively new. We know that oysters are very sensitive to concussion or shock; what then is the probable effect of dynamite, thunder, the continual passing of trains, or the discharge of heavy artillery? The crash of cannon is so severe that if large guns were discharged off Brighton, there would be scarcely a sound pane of glass left in the town. And as sound-waves are propagated through water more strongly than through air, they may be supposed to act with considerable violence on such delicate organisms as the spawn of oysters. The slug, a gasteropodous mollusc, is well furnished with apparatus for hearing, seeing that its under-surface contains two rows of fibres and cells which seem to be the analogues of Cortis rods, and with which the creature undoubtedly detects a noise. The jelly-fish has a row of bell-like cells all round its rim, which seem to give the creature an idea of its position in space so that it can keep itself horizontal. If so, we have in the jelly-fish the earliest analogue of the semi-circular canals, just as we find in molluscs the simplest representative of the rods and otiliths. When the sea is covered with floating jelly-fish it would be possible to notice the effect among them of the report of a heavy gun.

Something probably remains to be learnt of the effect of thunder, not only on young oysters, but also on the fry of all fish. When a thunder-storm clears the air of insect life for a while, as it is popularly held to do, is it the thunder or the lightning that does the deed? It can hardly be the lightning; its course through the air is not sufficiently pervading. The shock of the thunder-clap is far more expansive and comprehensive, and its concussion which makes our windows rattle must be enough to paralyse a delicate insect and bring it to earth as a squirrel is paralysed by a smart blow on a tree. And the shock that is strong in air would be stronger still in water, and the effect would be very serious on the minute and delicate creatures of the sea.

Gentlemen, my task is done. If I can excite your interest in this important industry, the best natives may soon be selling at five a penny, as they used to be sold 100 years ago.

Ladies and Gentlemen—May I trespass for one moment from my beaten path by making one little suggestion for the future? It is summed up in two words "Private enterprise." Those beds that have been depleted and destroyed for the sake of immediate gain, with that reckless disregard of the future for the oyster-fishing of this country, surely demands a little thought; let us hope that careful enterprise which may perhaps be slow at first, will surely make strides some day, and build up once more a lucrative industry. Professor Brooks remarked—"Enterprise" the world ever teaches, that the most effective agent for the preservation and development of national wealth is private ownership. From the Americans and French much can be learnt, for in the former country an acre of good oyster ground can be rented for a dollar a year, and in France for a smaller sum still. Why should we not follow this example?

LECTURE 13.

(Reprinted from the Official Catalogue to the Exhibition.)

FISH AND FISHERIES,

BY

J. T. CUNNINGHAM, ESQ., M.A.,

The Marine Biological Association.

FISH AND FISHERIES.

It is a natural consequence of the fact that fishes live in the water, that we are unable to domesticate them and control the conditions of their life for our own purposes so completely and successfully as we can domesticate and control the creatures that live on the land. Even the birds of the air are not so difficult to bring under subjection as the fishes of the waters. Primitive man controlled nothing, but took wild fruits, wild animals and fishes as best he could in their natural state. Civilized populations are fed and clothed with the bread, milk, mutton, beef, wool, and a thousand other commodities produced by elaborate systems of cultivation, perfected by long ages of experience. But we obtain our supplies of fish now just as primitive man did in the prehistoric ages; we wrest them violently from the hands of nature. The primitive hunter has become a scientific agriculturist, but the fisherman is a fisherman still. Science has been applied to the fishing industry, of course, and the civilized fisherman of to-day goes to work in a manner very different from that of the primitive savage; but the improvement and extension has been in the means of capturing fish, not in their production. Like everything else at the present day, fish-catching is largely done by steam, and on an enormous scale. But inasmuch as we have hitherto done almost nothing towards husbanding the supply of fish, it has become a question whether our progress in the means of capture has not reached its limit, and we are forced to turn our attention to the study of the source of the supply.

In the sea, as on the land, different animals have different modes of life, for which they are specially fitted by peculiarities of structure. The various modes of fishing correspond to the different habits of the fish to be caught. Pilchards are no more to be caught with the beam trawl than the conger with a drift net. It may be said in a general way that there is a different kind of fish for every different supply of food existing in the waters, on which fish can live. Inasmuch as the water of the sea is swarming with minute creatures of various kinds, fishes like the pilchard and herring and sprat, which roam about in shoals, can live upon these by swallowing them in very great numbers. The mackerel lives partly in a similar way. These migratory gregarious fish are caught by the drift net and seine. The bottom of the sea is the home of a large number of kinds of fishes, which find their food there; the flat fishes, and the skates and rays which rest upon and glide over the bottom, and many different kinds, as hake, gurnard, whiting, etc., which hover above the ground. These fishes, all caught in the beam trawl, belong to various very distinct families, the members of which have a strong family resemblance to one another. The flat fishes, plaice, sole, turbot, brill, megrim, flounder and dab, all form one family, resting on one side and having the two eyes on the other. The gurnard, of which there are six kinds, among them the grey gurnard, red gurnard, tub and piper, form another family. The whiting, pollack, and hake belong to another, all having three fins above and two below. The skates and rays, although flat, like the flat fish, have only an apparent resemblance to the latter, belonging really to the dog-fish tribe. The flat fishes are flattened from side to side, the skates from back to belly, and the breadth of the skate is made up by its enormous front fins, the wings, as they are called by the fishermen. The dog-fish tribe are distinguished from other fishes by very striking differences; they are white in parts, but never silvery; they never

have over-lapping scales, but only spines and prickles in the skin; they have no true bone in their skeletons, but only cartilage or gristle, and finally, their breathing holes, five in number, open directly on the surface of the skin, not being covered over by a bony flap, as in other fishes.

Nearly all fishes are carnivorous, feeding on other animals in the water, but many kinds feed on other fishes or the larger kinds of lower animals, such as crabs and shell-fish. Such kinds are predaceous, and correspond in some degree to the birds of prey among birds. These fishes have large mouths and snap at their prey suddenly. It is these kinds which can be taken with baited hooks. There are two principal kinds of fishing with hooks, long lining and hand lining. In the latter the line is let down vertically or trailed from a boat, and the fish is hauled in when hooked. The long line consists of a long, strong cord or rope, to which large hooks are attached by pieces of thinner line at intervals, and the whole series of hooks is let out and allowed to lie on the bottom for a time, when the fish hook themselves. Many fish taken by the trawl are also taken by the hook, for instance, whiting, bream, gurnard, and hake by hand lines, and skate and ling on long lines, but there are some fish which are taken principally by the hook. Among these is the conger, which belongs to the eel family, distinguished by having a single fin along the back and no hinder paired fins, and by their long, round bodies. Pollack are also taken on the hook, and the mackerel after its spawning is over, and the bass which belongs to the same family as the common river perch, is taken chiefly in this way.

It may be useful to give at this point a more complete and comprehensive sketch of the principal subdivisions of the whole class of fishes. It must of course be remembered that only those animals are fishes which breath water by means of gill openings at the side of the neck, the water being taken in usually by the mouth, and passing out of these openings over the delicate filaments,

richly supplied with blood, with which the openings are fringed. Thus porpoises and whales are not fishes, not breathing water by gills but breathing air by means of lungs. They are in fact aquatic beasts or mammals, and they suckle their young like dogs or cats. Seals are even less likely to be mistaken for fish, having the limbs as well as the other characteristics of mammals.

But there are certain creatures which breathe by means of gills which it is advisable to exclude from the true fishes; these are the lancelet, and the lamprey tribe: they have no true jaws, and this deficiency separates them from the fishes. The principal division of the true fishes are (1) the dog-fish tribe, including the sharks and skates, to which I have already referred; (2) the ganoids or sturgeon tribe, which usually have instead of scales flat long plates on the skin forming an armour; (3) the tropical mud-fishes, which approach in some degree to the amphibia such as frogs and toads, their air-bladder being partly used for breathing air; (4) the bony fishes, which are the commonest and most familiar in our own country.

The bony fishes first separate into two divisions: (*a*) those in which the air-bladder communicates with the gullet, (*b*) those in which the air-bladder is entirely closed. It is an interesting fact that the fishes of the first division are the least altered from the original condition of fishes as shown by fossils, and are inhabitants for the most part of fresh water.

The fishes of this division are soft rayed, that is to say the fin rays are jointed and flexible, except the first one or few of the dorsal, anal and pectoral, which are in many species strong rigid spines. In these fishes the hinder pair of the paired fins called the pelvic, and corresponding to the hind limbs of a quadruped, retain their original and proper position at some distance behind the front or breast fins, whereas in the other division the pelvic fins are found in a much more anterior position, close to or in front of the breast fins.

The principal families are:—

(1) The Carp family, to which belong all our commonest river fishes, such as the carp, closely allied to which is the gold fish, the barbel, the gudgeon, the roach, the chub, the dace, the minnow, the tench, the bream, the bleak, and the loach. In the fishes of this family there is only one fin on the back, which in the carp is long, in others short. The mouth is small, the lips thick and fleshy. Many of the species live largely on vegetable food.

(2) The Pike family, of which only one member, the common pike, occurs in this country. The snout is broad and flat, the mouth wide and deep, this fish being predaceous and living on other fishes. There is a single fin on the back, placed far back near the tail, opposite the anal or ventral fin.

(3) The Salmon family, including the salmon, sea trout, river trout, the charr, the smelt, pollan, vendace, grayling, and the argentine. The mouth is large, but the snout and head rather narrow, There are two fins on the back, of which the hinder one is small and without rays.

(4) The Herring family, including the herring, pilchard, sprat, anchovy, and shads. These have a single dorsal fin, which is short and placed near the middle of the back. The scales are thin, smooth, and easily detached. The teeth are small or absent, and when the mouth is open the sides of the upper jaw in all except the anchovy come forward and close the sides of the gape.

(5) The Eel family, of which only the fresh water eel and the marine conger occur commonly in this country. The dorsal and anal fins are continuous with the tail, and surround a great portion of the length of the body. The skin is slimy, without visible scales, and the hinder pair of side fins is wanting.

The second division of bony fishes, those with closed air-bladders, may be sub-divided into five distinct orders. The first of these is distinguished by the total absence of spines in the fins of the fishes belonging to it. In this order the second pair of side fins are near the head, either in front of or close to the first pair or breast fins. In other words, it might be said that in these fishes the legs are in front of or close to the arms. This order contains two families of the greatest importance in the fisheries, namely the cod family and the flat-fish family. The principal families are:

(6) The Cod family, including the cod, the haddock, the pouting, the power or poor cod or bib, the whiting, the coal-fish, the pollack, the hake, the ling, the rocklings, the torsk. The more typical members of this family have three fins on the back and two beneath the body behind the abdomen. The vent has a forward position. In the hake and ling the two posterior dorsal and the two ventral fins are represented by one long fin, in the rocklings and the torsk there is one fin extending the whole length of the back. The scales are thin and smooth, of moderate size or small; the mouth is large. Many of the species have a barbel on the chin.

(7) The Sand-Eel family. The fishes of this family may be regarded as fishes of the cod tribe more elongated and fitted for burrowing or concealing themselves in holes. There is only one dorsal fin and one anal; the second pair of paired fins, as in the eel, is wanting. The only forms of importance are the sand-eels or launces, of which three kinds have been distinguished.

(8) The Flat-fish family, including the plaice, flounder, dab, lemon sole, witch, sole, thickback, halibut, long rough dab, turbot, brill, megrim, scald-back,

and others. These fishes lie on one side on the ground, in some the upper side being the right as in the plaice, in others the left as in the turbot and brill. The two eyes are on the upper side, and the lower side is white. There is one dorsal and one ventral fin, extending nearly the whole length of the body. In some, as in plaice and sole, the teeth are present only on the lower side; in others, as in the halibut and turbot, the teeth are equally developed on both sides.

The next order is that of the spiny-rayed fishes, in which a number of the foremost rays of the fins have the form of strong rigid bony spines, in which no trace of jointing can be seen. In these fishes it is often the case that the first dorsal or back fin consists wholly of spines, which can be raised and lowered at the will of the fish. The principal families are:

(9) The Perch family, including the fresh water perch, and the ruff, the bass (marine) and other less familiar marine fishes. In the perch and bass there are two dorsal fins, the front one spiny, but in the others the spiny fin and the soft fin are continuous with one another. The scales are usually furnished with tooth-like projections.

(10) The Mullet family. Only one British fish belongs to this family; namely, the red mullet, which occurs in two varieties, the striped and the plain. There are two fins on the back, at a considerable distance apart, and two stiff barbels below the chin. The scales are large and strong. The fish is red, the stripes in the striped variety yellow.

(11) The Bream family, including the sea-breams. These fish have a single dorsal fin, the front part of which consists of spines. The common sea-bream and others have rounded molar teeth at the sides of the jaws for crushing hard food.

(12) The Gurnard family, including the grey gurnard, the red gurnard, the piper, the tub, and others. These fishes are well distinguished from others by their rough bony heads projecting into powerful spines, and the remarkable fact that the first three rays of each breast-fin are separate and separately movable. With these the fish *walks* on the sea bottom somewhat like an enormous insect. There are two dorsal fins, the second of which, and the ventral, are long and opposite one another. Except in the grey gurnard, the colour is bright red. The tub has large breast fins very beautifully coloured on the posterior surface, and appearing, when spread out, like a butterfly's wings.

(13) The Angler family includes only one British fish, the well-known angler, which has a bulky broad body, stumpy fins, and an enormous mouth. The spines of the front dorsal are separate, and appear to be used as lures to attract the angler's prey. It lies concealed and half buried at the sea-bottom.

(14) The Mackerel family. This family includes not only the common mackerel, but also the huge tunnies which are abundant in warmer seas, and occasionally occur off our coasts. The distinguishing feature in this family is that there are two principal dorsal fins placed far apart, and behind the second and behind the anal fin a series of minute finlets. They are all voracious and gregarious, feeding largely on other fishes. There is a keel on each side of the root of the tail. The remora, which has a sucking apparatus on its head, and fixes itself by its means to sharks, belongs to this family.

(15) The Horse Mackerel family includes the horse-mackerel, the little boar-fish so common on the Cornish coast in summer, and the curious pilot-fish,

noted for its fondness for the company of sharks. In this family there are two dorsal fins, of which the first is sometimes rudimentary, and the lateral line is in some, as in the horse mackerel, covered with large scales.

(16) The John Dory family, of which only this one species is British. The dory is remarkable for the height and thinness of its body, owing to which it approaches its prey slowly without alarming it, and then seizes it with a sudden snap. The membrane of the spinous portion of the dorsal fin is prolonged into narrow ribbons or streamers. There is a round conspicuous dark spot on each side of the body.

(17) The Goby family contains the gobies, small shore-haunting fish of no commercial value.

(18) The Blenny family, characterised by their elongated dorsal and anal fins, and tough scale-less skins, are also commercially unimportant.

(19) The Atherine family includes a fish, the atherine, commonly known as the smelt in Cornwall, although it is very different from the true smelt, which belongs to the salmon family. The atherine has two dorsal fins close together, the hinder paired fins a little behind the breast fins, and a bright silvery streak down the sides. The body has a delicate transparent appearance.

(20) The Grey Mullet family. The grey mullet, in spite of their name, have no close similarity to the red mullet, although they belong to the same order of fishes. They have very minute teeth, and feed chiefly on vegetable substance, delighting in harbours and foul waters. They have the usual dorsal fins of this order, and are bluish in colour with dark stripes running lengthwise.

The third order of the fishes with closed air-bladders has been distinguised by the peculiarity that certain of the tooth-bearing bones in the throat are fixed together; but the independence of this order is doubtful. Among the families placed in it are:—

(21) The Wrasse family, containing weed-haunting fish of bright colouring, but not used to any extent as food. These fish have thick lips, and a long single dorsal fin.

(22) The Gar-fish family includes the gar fish, saury pike, and the flying fishes. In these fishes there is only one dorsal fin, placed near the tail opposite the anal, and having all the rays soft and jointed. In the gar-fish and saury pike both jaws are prolonged, forming a beak, but in the latter there are finlets behind the dorsal and ventral fins, which are not present in the gar-fish. In the flying fish the breast fins are enlarged and act somewhat as wings when the fish leaps into the air.

The 4th order is distinguished by the peculiar structure of the gills, the filaments of which form bunches or tufts. Only one family of this order is British, namely:

(23) The Pipe-Fishes. These fishes are very elongated in form and slow in their motions; the tail is thin and slender and the tail fin small or absent, so that they cannot swim actively as other fishes do. Instead of scales some of them have large bony plates in the skin which give the body an angular wooden appearance. There is a single dorsal fin, and the second pair of side fins is wanting. The snout is prolonged into a tube, at the end of which the jaws are placed. The male has usually a pouch beneath the tail in which the eggs are carried until hatched; but in some species there is no pouch, and the eggs are simply glued to the

skin of the male's body. One form has a shape suggesting strongly that of a horse, and is called a sea-horse. The elongated forms are common on the shores of Cornwall, but the sea-horse has not been found there, although common in Guernsey and on the coast of Ireland.

The 5th order of these fishes is distinguished by the immovable union of the bones of the jaw. Two families may be mentioned.

(24) The File-Fish family includes the file-fish and the curiously shaped cow fish of the tropics. The skin contains strong scales, forming a hard dense covering. The teeth are large, few in number and projecting.

(25) The Sun-fish family contains the sun-fish and the globe-fish. The bones of the jaws form a beak covered with ivory-like substance but without teeth. In the globe-fish the skin is covered in the lower parts of the body with four-rooted spines, and the fish blows itself up with air in the form of a globe. The globe-fish has been occasionally taken in Britain. There are two sun-fishes, the truncated sun-fish, and the common. They are of large size, 3 to 6 feet in length, have very little thickness, and great height, the body having the form of a cake rather than of a fish. The skin is rough, the mouth small, the jaws forming a beak. There are a dorsal and anal fin opposite to one another at the end of the body, but the second pair of side fins are wanting. As might be expected, these fish are only capable of slow movements, and live in mid-ocean, occasionally drifting near our coasts,

Very naturally, owing to the greater facilities for observation, the eggs and mode of breeding of fresh water fishes were studied and known long before those of marine fishes. It was observed that with certain excep-

tions the eggs were fertilized by the male after they had been deposited by the female. The eggs of the majority of fresh water fishes are attached to aquatic plants, and receive no care from the parents. The attachment is effected by the adhesion of the sticky surface of the membraneous capsule which surrounds the egg, and which is burst when the young fish is hatched. These eggs are small, and each female produces a large number, spawning only once in the year, usually in spring. The salmon ascends th upper streams of rivers in order to spawn, and like the other members of its family, buries its eggs in heaps of the loose gravel of the river bed. The eggs are of considerable size, nearly ¼-in. in diameter, and are not adhesive, but heavy, sinking by their own weight in fresh water. They take about three months to hatch, being deposited about November and hatched in February. The possibility of artificially fecundating the eggs of the salmon was discovered at the beginning of this century, and has since been extensively practised, as a means of obtaining fertilized eggs in any desired numbers. The possibility depends on the facts (1) that fertilization is naturally effected after the eggs have been shed; (2) that when the fish are "ripe," both milt and eggs can be forced from the fish by gentle pressure on the abdomen, without injury to either the eggs or the parent. The eggs can afterwards be kept healthy until they are hatched by proper treatment in suitable apparatus, the essential condition being that a stream of clean water is kept constantly flowing over them. The method now accepted as the best is to place the eggs on grills made of glass tubes at the bottom of shallow wooden hatching boxes, supplied with a constant stream of spring or river water.

Many fishes of the shore, such as gobies, blennies, and the large lump-sucker, have adhesive eggs like those of fresh water fishes, and in the majority of these the male fish keeps guard over the eggs, sometimes constructing a shelter or nest for them, and fanning them with his

fins to keep a current of water moving over them. The sticklebacks, both the little Gasterosteus of fresh water, and the marine shore-haunting large form, the 15-spined stickleback (Spinachia vulgaris), deposit their eggs in nests constructed among the weeds by the male, who keeps guard over the nest until the young are hatched.

Until the year 1862 absolutely nothing was certainly known with respect to the breeding of any marine fish which had a value in the market. The fish whose mode of breeding was then ascertained was the herring. The fishermen of the shores of the Firth of Forth stated that the spawn of the herring was deposited on the sea-bottom, and was destroyed by the beam-trawl. The Scottish Fishery Board instituted an investigation of the matter which was carried out by Professor Allman, who searched the bottom by means of divers and dredges to discover the spawn. He obtained it in large quantities near the shores of the Isle of May, and satisfied himself that it was the spawn of the herring. His report was not published in full, but his results are summarised in the Report of the Royal Commission on Trawling for Herring, published in 1863. No figures or complete description were published at this time, but the character and fully development of the eggs of the herring have been described since.

Even at the present time, however, the investigation of the spawning of the herring has by no means been exhausted. Where the spawning beds are known they are on rough ground, consisting of gravel and stones at no great distance from the shore, and in somewhat shallow water. In Scotland, in addition to the locality above mentioned, one other spawning bed is known and has been examined by naturalists, namely, off Ballantrae, in Ayrshire, on the west coast. In the Baltic, in the neighbourhood of Kiel, the localities where herring spawn is deposited have been ascertained and examined. But the herring is remarkable in having two spawning periods,

one corresponding to the great summer fishery, and the other to the winter and spring fishery. Both the spawning beds known in Scotland are visited only by the spring herring in February and March, and in this country the herring spawn has not been examined by naturalists in any other place. It is obvious enough that the enormous shoals of herring occurring on the east coast of Britain in August, September, and October, spawn not far from where they are caught. At all the fishing places the herring are taken at a certain period of the fishery in the ripe condition, with the spawn running from them in streams, and soon after they are taken in the spent or shotten condition. But the localization of the spawning places is still to be carried out. On the south coast, on the coasts of Devon and Cornwall, herring are not taken or found in summer, but only in winter, from October to February and March. At Plymouth they are found to be ripe in January, and at this time congregate in Bigbury Bay, where I have taken the spawn from the fish, artificially fertilized it, and hatched it in the Laboratory. But although we have made repeated endeavours we have never succeeded in dredging up any herring spawn. The newly hatched larvæ or baby fish we have taken abundantly enough in the neighbourhood, near the surface of the sea, and I have obtained the fish at later stages which indicate its rate of growth.

In 1864 or 1865 the remarkable discovery was made in Norway that the spawn of the cod floats in the sea suspended in the water from the surface to various depths downwards, each egg being separate and free, and the multitudes scattered and dispersed by the waves. These eggs are minute and of glassy transparency, so that they cannot usually be discerned by the eye looking at the sea from a boat. Each egg is little more than $\frac{1}{20}$th in. in diameter. This discovery was made by Professor G. O. Sars, still Professor of Natural History at Christiana, who was commissioned for several successive years by the

Norwegian Government to make investigations into the fisheries and the fish which formed their object. In a subsequent year Sars found that the mackerel's eggs were of the same character as those of the cod, but were distinguished by having a single globule of oil in the yolk. Since then the discovery has been extended to nearly all the bony fishes caught for the market, except the herring and the conger and eel, the spawn of the former being fixed to the bottom, that of the latter being still unknown. I refer here only to the bony fishes, not to the skates and dog-fishes, of which some bring forth their young alive, and others lay large eggs enclosed in horny capsules oblong in shape, with processes at the corners, and several inches in length.

By means of a conical net made of muslin or silk cloth, numbers of floating eggs of fishes can be taken from the sea at almost any period of the year, and many of those belonging to different kinds of fish are so much alike that there is considerable difficulty in distinguishing them. They can also be obtained by squeezing the ripe fish, and artificially fertilised as easily as the eggs of the salmon or herring, and can be hatched on shore in suitable apparatus. The time occupied by their development is short, varying from two days to a fortnight or three weeks, according to the kind of fish and the temperature. As the eggs are buoyant it is necessary to keep them in a vessel with a bottom pervious to water, and to have a constant supply of sea-water delivered into the vessel to keep the eggs healthy. They can be even hatched in a bottle full of sea-water, but the water is liable to go bad and the eggs to die. For practical purposes I know of no more satisfactory apparatus than the box devised by Captain Dannevig, of Arendal, Norway, an example of which is in the Exhibition, exhibited by myself on behalf of the Marine Biological Association. This apparatus consists of a water-tight box, about eight feet long by three feet broad, divided

into a double series of square compartments, each of which contains a movable box, the bottom of which is formed by a sheet of hair or silk cloth. The eggs are placed in the movable boxes and a current of water flows through the whole apparatus, which is placed at a certain inclination, from each compartment into the movable box of the next. At Captain Dannevig's establishment many millions of eggs of the cod are annually hatched with apparatus of this kind, the fry afterwards being turned out into the sea.

It has been already stated that these floating eggs are not usually visible in the sea, although in certain circumstances, when the weather is calm and the eggs in great numbers, they may form a visible scum on the surface. Other floating things are, however, frequently mistaken by fishermen and others for floating spawn. For instance, in early summer off the coast of Cornwall, there are frequently seen great quantities of a pinkish scum, which is found to consist of small round globules. This stuff has often been brought to me as mackerel spawn. It is not the spawn of fish at all; the little globules being the perfect form of a lowly organised member of the animal kingdom, which never develops into anything different, It is called Noctiluca, which is Latin for night-light. because it has the power of what the learned call phosphorescence, and the fishermen "briming," affording when disturbed on a dark night, a wonderful and beautiful display of light, especially when, as I have seen it, scattered about by the gambols of a shoal of porpoises. Fish spawn does not "brime," or give out light.

It is evident that these minute transparent eggs of fishes floating about in the water cannot be injured or destroyed by beam-trawling or any other kind of fishing operation. There is no doubt that a large proportion of them are destroyed, but of the dangers to which they are exposed we do not know much accurately. We know that migratory fishes, such as pilchard, herring or mackerel,

feeding on floating food, devour large numbers of these eggs, and that other classes of the floating population of the sea waters feed upon them, but we cannot yet form an estimate of how many per cent. escape all dangers until they are hatched.

In following the history of the lives of fishes, the period of development from the time of hatching to the stage at which the young fish, although small, has the same form and structure as its parent, is a very well marked period which it is convenient to consider as a separate chapter. For the young fish, when it is first hatched, is very different from its parent, and therefore from the perfect form into which if it survives it will develop. It is a slender transparent delicate little creature. Fish which hatch from large heavy or adhesive eggs are hatched in a more advanced condition than those which come from floating eggs, but in every case the newly hatched fish is very imperfect, as the maggot is imperfect compared with the fly, or the caterpillar compared with the butterfly. The newly hatched fish has no bones, it has the yolk bag attached to its abdominal region behind the head, and instead of the fins of the adult it has simple membranous expansions. One of these membranous bands extend down the back of the fish round the tail and forwards again to the yolk-bag. The newly hatched sole for instance is not quite one-sixth of an inch long. The period from the shedding of the eggs to hatching is at ordinary temperatures 9 or 10 days.

At first, the fish hatched from a floating egg has no mouth, but this appears a few days after hatching. During this time the little creature is nourished by the yolk in the yolk-bag, which is used up and gradually dwindles away. When the yolk is all gone the little fish begins to feed, and very minute are the particles which it is able to swallow. It feeds chiefly on the young forms of the lower animals in the sea. Then as it grows larger the bones develop inside it in their proper places, and the

growth of the fin rays causes the fins of the perfect fish to appear. In ordinary fish, such as the mackerel or whiting, this is all that takes place. The eyes are present one on each side of the head at hatching, and they simply grow like the rest of the fish. The body loses its transparency, and the skin gets its scales and colour, and we have a little silvery fish an inch or so long, which with sufficient attention we can recognise as whiting, mackerel, or whatever it may be.

But in the flat-fishes such as the sole, plaice, turbot, etc., a more wonderful change takes place. When the bones and fin rays begin to appear in the little transparent flat-fish, the eye of one side begins to move out of its first position towards the upper edge of the head, and soon after this the young fish begins to rest from time to time on the bottom on one side. The sole rests on its left side, the turbot on its right. The eye of the lower side at last passes completely over on to the upper, and so we find in the full-grown flat-fish both eyes on one side of the body and none on the other. When this change is completed the young flounder is about three-fifths or four-fifths of an inch long, and the young sole about the same size. The turbot and brill grow more quickly, although not larger thon the sole or plaice when first hatched, and they swim more at the surface during their transformation, so that they are commonly taken up to an inch or more in length with one eye still on the edge of the head, not yet in the position it has to reach.

The exact time occupied in this process of development has not been ascertained, but it is certain that it is about two months. For it is known that most fishes, except the herring, have only one spawning period in the year, and the young fish are found regularly every year about two months after the commencement of the spawning season. Thus the flounder begins to spawn in February, and the young flounders in various stages up to that in which they have reached the final condition are found in

numbers in April. The young fish have to be sought in various ways, but in certain places, as in the harbour at Mevagissey, and on sandy flats elsewhere, young flounders, plaice, and soles can be taken in great numbers in the shallow pools left at low tide. Some kinds of fishing take young fish in large numbers, for instance, whitebait are simply the young stages of herrings and sprats, with a few other kinds, such as gobies, mixed with them. The young turbot and brill before their development is finished, and before they have taken up their abode at the bottom of the water, are so large that they can frequently be seen at the surface of the water from a boat at sea, and strange to say these most valuable of fishes at this stage are carried with the flood-tide into harbours and creeks, where even if they are not captured it must be supposed that they would be killed by dirty water and want of food. Young turbot and brill are seldom taken at a later stage on the bottom in Plymouth Sound, but every year some dozens of them are brought up in the earlier condition alive to our Laboratory by boys or men who have simply dipped them up in bailers from the side of a boat, or from pier steps in Sutton Pool and other parts of the Sound. A number of these young stages of flat-fish and others of various kinds are to be seen in the collection exhibited by the Marine Biological Association.

Now in regard to the question of the maintenance of the supply of our more valuable marine fishes, there can be no more important consideration than the fate of these young specimens. If we could know thoroughly and exactly what are the proportions which get killed and which survive in the natural state, and could then ascertain accurately what are the numbers annually taken by the fishing industry, we should have some basis on which to construct a policy with the object of getting as much of each kind of fish as possible for our own consumption. We are feeling after this knowledge, and in the meantime every now and then a loud demand goes up to the Government from the fishing industry to stop something

which threatens the destruction of the fish supply, or to do something which will be sure to increase the supply. In most cases these demands are not founded on any extensive knowledge, and sad to say, there are even indications of impatience on the part of those concerned in the industry when they are asked to attend to the small amount of knowledge obtained by so much labour and expense up to the present time.

At present the burning question in connection with fisheries is the destruction of young, undersized and immature fish. This question naturally falls into two parts—(1) the destruction of fish too small to be of value in the market; (2) the destruction of fish which fetch a price, small though it be, but which are too small to spawn, and much below the full growth of their kind. We may describe these two kinds as the useless destruction of small fish, and the improvident destruction. The former kind of destruction can only be effected on a large scale by small meshed nets, and as such nets are not worked in the open sea, it goes on chiefly along the shores. As a matter of fact useless destruction is principally due to fishing for shrimps, although some may be effected by ground seining. Not all kinds of fish indiscriminately are to be found in the neighbourhood of the shores, but the young of certain kinds live there in large numbers. It was mentioned above that the flounder, plaice, sole, turbot, and brill are found near shore when young. On this matter a large amount of evidence has been collected, partly from experimental fishing carried on for the purpose, partly from examination of the contents of shrimp nets. The result is to show that for the first six months after hatching the young of the plaice and flounder are found only in the neighbourhood of the shore, in bays and estuaries especially. Dabs, soles, turbot, and brill, are found with these, but not in such large numbers. Dabs, certainly, and soles, turbot and brill, presumably, are distributed at this stage of life to a considerable distance from the coast. The data obtained refer for the

most part to the first half of the year, and as the sole, turbot, and brill spawn from March to August, it is certain that many of the young of these kinds taken are derived from the previous year's spawning. As an example of the relative proportions of the different kinds taken in the Humber by a hand net, the following figures may be given :—With 4 quarts of shrimps were taken 896 plaice under 4½ inches long, 6 flounders under 5 inches, 3 dabs under two inches, 4 soles under 4 inches, 2 brill under 5 inches. Until lately, the young of the merry sole had only been taken in deep water at a great distance from land, but last autumn, Mr. Holt found a few, not more than 16 in one haul, in the estuary of the Humber. The young of the megrim, the witch, and the long rough dab have never been found near shore. Among round fishes, the forms whose young are taken by shrimp nets in inshore waters are the whiting, cod, pollack, and pouting. The whiting and cod are also taken in the North Sea, at a distance from shore, the young of the haddock have only been taken on off-shore grounds, not inshore.

The examination of such young fish as these naturally leads to the attempt to calculate how old they are and how long they take to grow. Some light has been thrown on this question, although it is exposed to considerable uncertainty, owing to the length of the spawning period, and the unequal rate of growth of different individuals. It is often possible to be certain that a number of fish, however small they may be, must be derived from the previous spawning period. The smallest fish taken at the beginning of the spawning season of their kind must be at least a year old or nearly, and it is equally certain that they cannot be more than one year old. This gives the least growth which takes place in a year. The greatest growth that takes place is more difficult to ascertain, but observations on flounders and other fish kept in the aquarium have shown what is the greatest growth reached in captivity, and the growth in the sea may be supposed to be not less than this. My own

observations tend to prove that no fish is capable of spawning at one year of age, and in captivity not all reach maturity at two years. Thus it may be reasonably inferred that a fish which is large for its kind is three years old, and may be more. This comparatively slow rate of growth considerably diminishes the effect of the fecundity of fishes, because the longer they take to reach the full-grown condition, the greater the chance that they will be killed before they reach it.

The large number of plaice which are proved to be immature, that is, incapable of spawning, and from 6 to 11 inches in length, taken in certain localities where the slope of the coast is gradual, shows conclusively that at least the majority of plaice in the sea do not spawn at one year of age. It is plaice of this age and size, and turbot at a corresponding size, which are principally taken by beam trawlers fishing in such localities. It is for the protection of such fish that the Devon Committee has been recently passing bye-laws, and the North Sea fishermen are anxious to find a means of stopping the destruction of similar fish on the eastern side of the North Sea. The objections to the wholesale destruction of such fish are forcible enough, but the question of the method of stopping it is not always easily solved.

It is somewhat more difficult to trace out the life histories of migratory fishes which swim in shoals, such as the mackerel, pilchard, herring, etc., than those of the more stationary fishes we have been considering. But some evidence of importance has been obtained with regard to these. It is a surprising fact in the first place that the eggs of the pilchard should be of the floating kind, considering how closely allied the fish is to the herring. This fact was believed but not proved by the Cornish naturalist, Jonathan Couch, as long ago as 1865, but he had not seen the actual spawn. In 1871 Mr. Dunn of Mevagissey, squeezed a ripe pilchard into a bucket of sea water, and saw the eggs float separately in the water

for a time. Later an Italian naturalist found floating eggs in the sea which he concluded to belong to fish of the herring family. But the final evidence on the question was obtained by myself at Plymouth, when I compared the eggs squeezed from the pilchard with others taken in the sea, and gave a figure and description which enable anyone with a miroscope to identify the eggs of the pilchard. The pilchard is found spawning far out at sea in summer from May to September or later. There may be two periods, but I know no evidence that this is so, not having found the ripe fish especially at two seasons. The ripe fish are not usually caught in large numbers, because pilchard nets are not shot at the place and season where the ripe fish occur, and only a few of the females are meshed in the mackerel nets in summer time. The pilchards caught near land for the market are never, in my experience at least, ripe spawning fish.

I have taken the very young pilchards, not many days old, in July, and traced some of the stages of their development to the perfect form. In November I have obtained older fish, 2½ to 3 inches long, which I think there can be no doubt were derived from the previous spawning season of the same year. At the same time of the year, November and December, there were taken in small meshed drift nets belonging to our Association, considerable numbers of pilchards 5 to 6 inches in length. I estimate that these pilchards were over one year old, and have little doubt that they occur in considerable numbers off the Cornish coast all the summer, just as they do off the opposite coast of Brittany. The pilchards of this size are the object of a special fishery on the French coast, where they are prepared in tins and sent to this country in the familiar form of tinned sardines. Pilchards are preserved in the same way in Cornwall, at Mevagissey, but larger fish are used, because there is not a sufficiently extensive market to encourage a special fishery with small meshed nets. It is absolutely certain that on the French coast the full grown sardine, which is fished in winter, is

as large as the Cornish pilchard. In the Mediterranean, however, the same kind of fish does not reach such a large size, it does not exceed 6 to 7½ inches.

The sprat has also floating eggs, but does not appear to wander so far abroad as the pilchard. It is found in estuaries in winter, and spawns at sea in the earlier part of the year, while its young when a few months old ascend rivers, and are largely taken under the name of whitebait with the young of the winter herring. The anchovy occurs off the Cornish coast in winter, but its spawn has not been found there. Curiously enough it spawns every summer in June and July in the Zuyder Zee, in Holland, and in the Mediterranean, but not in the English Channel.

The fishes whose histories are still most mysterious are the eels. It is known that eels go down to sea in autumn, and that young eels — slender, transparent, creatures, about two or three inches long—ascend the rivers in spring. The old eels are never seen to return, and it is suspected, indeed, it is almost certain, that they die after spawning; but the spawn has never yet been found. The male eel has been recognised, but not in the ripe condition. The male conger has been found among specimens kept in aquaria, in the ripe condition. It does not grow beyond 2-ft. 8-in. in length, all larger conger being female. The female, on the other hand, has never been obtained in the ripe condition from the sea, but when kept in the aquarium after growing to a large size, from 30 to 60 lbs. in weight, or even larger, she ceases to feed, and lives for about six months, absolutely fasting. She becomes enlarged with spawn, but dies without shedding it. When examined she is found to have enormously enlarged roes, the eggs nearly but not quite ripe, and she has lost her teeth, and her bones have become quite soft. The conclusion drawn from these facts is that the conger in the sea naturally breeds once, and then dies, and that in the aquarium the unnatural conditions cause her to die too soon.